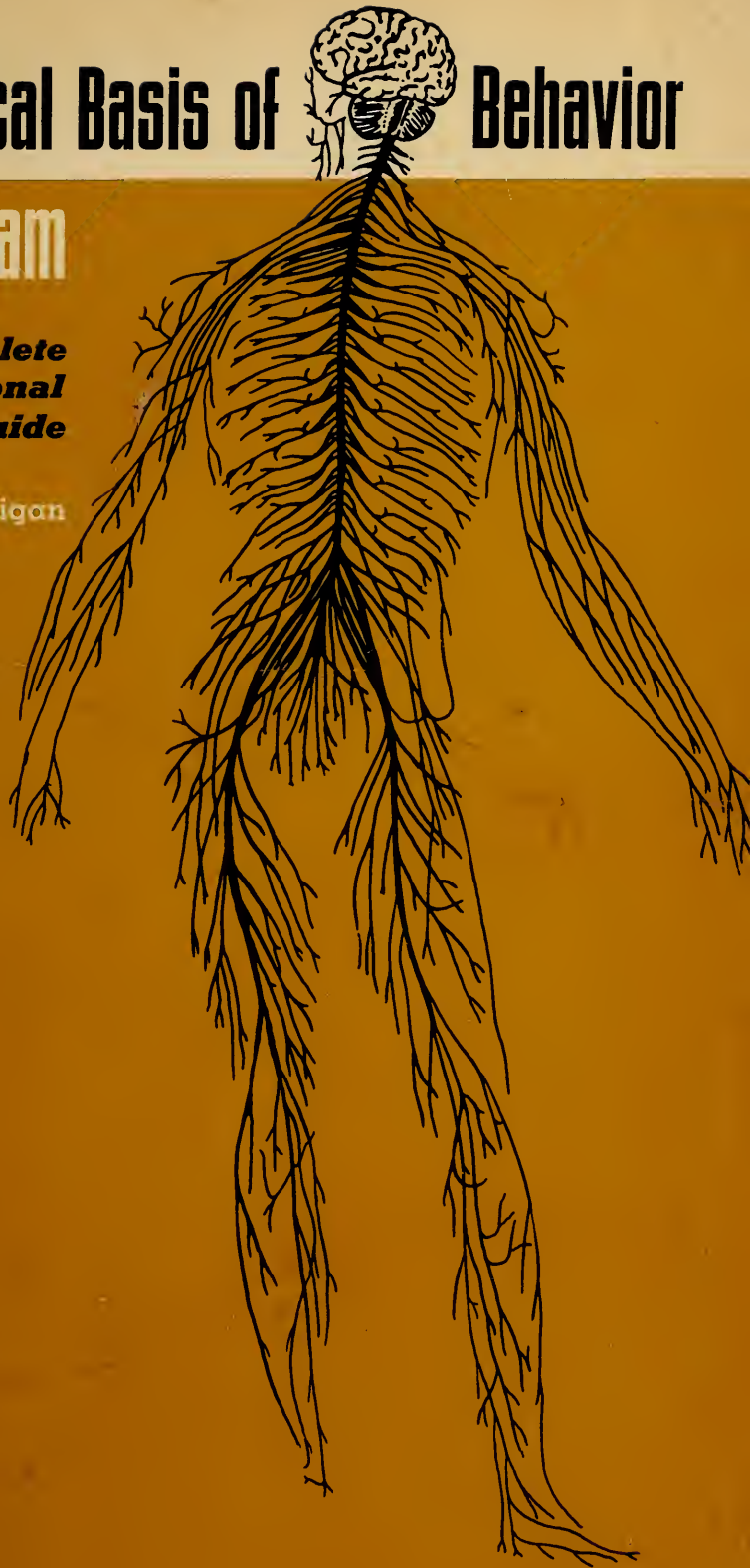


Biological Basis of Behavior

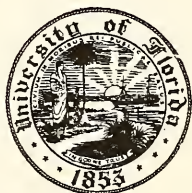
A Program

***A Complete
Self-instructional
Programed Guide***

F. J. McGuigan



UNIVERSITY
OF FLORIDA
LIBRARIES



BIOLOGICAL BASIS OF BEHAVIOR

A Program

PRENTICE-HALL INTERNATIONAL, INC., *London*
PRENTICE-HALL OF AUSTRALIA, PTY., LTD., *Sydney*
PRENTICE-HALL OF CANADA, LTD., *Toronto*
PRENTICE-HALL FRANCE, S.A.R.L., *Paris*
PRENTICE-HALL OF JAPAN, INC., *Tokyo*
PRENTICE-HALL DE MEXICO, S.A., *Mexico City*

BIOLOGICAL BASIS OF BEHAVIOR

A Program

F. J. McGUIGAN

*Professor of Psychology
Hollins College, Virginia*

PRENTICE-HALL, INC.
Englewood Cliffs, N. J.

© 1963, by PRENTICE-HALL, INC., Englewood Cliffs, N.J. All rights reserved. No part of this book may be reproduced in any form, by mimeograph or any other means, without permission in writing from the publishers. Printed in the United States of America. Library of Congress Catalog No.: 63-18114

C

✓

For RICHARD
"Mister Man"



Digitized by the Internet Archive
in 2010 with funding from
Lyrasis Members and Sloan Foundation

TO THE STUDENT

In this course, you will learn about the general physiological principles that underlie that part of nature that is of greatest interest to us all—human behavior. The goal is to better understand what goes on within us when we behave. More particularly, you will see how objects and events around you cause your sense mechanisms to send “messages” through your nervous systems, and finally to your muscles so that you can act.

In order to facilitate your learning, this course is programed for you. As education goes, programed learning is a new approach. To date, the results of programed learning have been extremely encouraging. One of its main ideas is that it breaks material into small pieces so that it is easy to handle. The small portions are quickly and easily learned and before you know it they all add up and you will find that you have learned a great deal.

The procedure is simple. First, cover the answers on the left-hand side of the page with the slider provided. Second, read item (frame) number one. Third, write the missing word in frame number one, and finally, move the slider down the page *just enough so that you see the answer to the first (and only the first) frame*. Then go through the rest of the frames in the program the same way.

A few cautions:

1. Do each item in its proper turn—do not skip a frame.
2. Avoid careless answers—think about what you write in each blank and try to connect your answer with the idea in each frame.
3. Make sure that you actually write out each answer.
4. Do not look ahead—it is very important that you *look at each answer only after you have written it in the corresponding item*. If you do look ahead, you will only be fooling yourself, and your learning will be retarded.
5. You should study the figures in detail, for they contain a large amount of valuable information. In order to help cement your learning, you will be asked at various places to draw the figures for yourself. In such cases, use any available 8½ x 11 paper.
6. In several frames, you might write in a word that means the same as the answer. Where you have written in a synonym for the answer, you should regard your word as correct.

This program has been thoroughly tested with a large number of students in several different kinds of biology and psychology classes. Without exception, the results showed that the classes not only learned a considerable amount, but also preferred this program to reading a book.

Now go ahead—you should not only profit from this course, but also enjoy it.

ACKNOWLEDGMENT

The author is truly grateful to the many students and colleagues who so generously gave of their time and talent in the development of this program. Unfortunately, space does not permit the naming of all these individuals; however, special thanks is extended to Allen Calvin, Vincent Dethier, Edward Green, and Robert Silverman for their professional comments, and to Linda Devin and Adelaide Johnston who offered extremely thorough and valuable criticism. Thanks, too, to Richard Popp who assisted in ways too numerous to specify, and to Charlotte Collings for her expert secretarial performance. Finally, the author wishes to acknowledge his great indebtedness and sincere appreciation to Hollins College for providing the stimulating atmosphere in which he worked.

F. J. McGUIGAN

CONTENTS

To the Students	vii
Acknowledgment	ix
Pronunciation Key	xiii

INTRODUCTION

I	Overview	1
---	----------	---

RECEPTORS

II	The Ear	14
III	The Eye	28
IV	Olfaction	42
V	Gustation	52
VI	The Cutaneous Senses	61
VII	The Kinesthetic Sense	79
VIII	The Vestibular Sense	88

xiii

THE NERVOUS SYSTEMS

IX	The Neurons and the Nerve Impulse	100
X	Electrical and Chemical Aspects of the Nerve Impulse	116
XI	The Central Nervous System— The Spinal Cord	142
XII	The Central Nervous System— The Brain	151
XIII	Neural Activity and the Central Nervous System	165
XIV	The Peripheral Nervous System	191

EFFECTORS

XV	The Muscles	198
XVI	The Glands	215

BIOLOGICAL BASIS OF BEHAVIOR

A Program

Pronunciation Key

The symbol ('), as in **moth-er** (mŭth'ər), is used to mark primary stress; the syllable preceding it is pronounced with greater prominence than the other syllables in the word. The symbol (ˈ), as in **grand-moth-er** (gränd' mŭth'ər), is used to mark secondary stress; a syllable marked for secondary stress is pronounced with less prominence than the one marked (') but with more prominence than those bearing no stress mark at all.

ă act, bat

ā able, cape

â air, dare

ä art, calm

b back, rub

ch chief, beach

d do, bed

ĕ ebb, set

ē equal, bee

f fit, puff

g give, beg

h hit, hear

ĭ if, big

ī ice, bite

j just, edge

k kept, make

l low, all

m my, him

n now, on

ng sing, England

ŏ box, hot

ō over, no

ô order, ball

oi oil, joy

ōó book, put

oo ooze, rule

ou out, loud

p page, stop

r read, cry

s see, miss

sh shoe, push

t ten, bit

th thin, path

th that, other

ŭ up, love

ū use, cute

û urge, burn

v voice, live

w west, away

y yes, young

z zeal, lazy, those

zh vision, measure

ə occurs only in unaccented syllables and indicates the sound of
a in alone
e in system
i in easily
o in gallop
u in circus

INTRODUCTION

Section I: Overview

- organism* 1. Scientists are interested in studying all organisms. A dog is an organism, a chimpanzee is an organism, and a man is an _____.
- species* 2. A SPECIES (pronounced spě'shǐz) is a group of organisms that have certain characteristics in common. There are many different _____ of organisms in the world.
- organisms* 3. These species range from very simple one-celled organisms to highly complex multi-celled _____.
- organisms* 4. The species called *Paramecium caudatum* is composed of a group of one-celled _____ that have certain characteristics in common.
- species* 5. Men are organisms that belong to the _____ called *Homo sapiens*.
- species*
organisms
characteristics 6. *Homo sapiens* is a _____ that is made up of highly complex multi-celled _____ that have certain _____ in common.
- behavior* 7. Clearly all sciences differ in some respects. But a number of sciences have a common interest in studying the BEHAVIOR of organisms. PSYCHOLOGY is one science that investigates the _____ of organisms.

- behavior; organisms*
8. While psychology is primarily concerned with studying the _____ of _____, PSYCHOLOGISTS are also interested in the internal “workings,” or FUNCTIONS, of organisms.
- functions/works psychology*
9. While psychology focuses on how man behaves, PSYCHOLOGISTS are also interested in how the brain FUNCTIONS (“works”). An understanding of how the brain _____ is important to the science of _____.
- psychology*
10. Similarly, psychologists study the functions of other organs of the body. How the eye and the ear function is of interest to the science of _____.
- psychologists*
11. The scientists who study psychology are called _____.
- organisms*
12. The science known as physiology is also concerned with studying the behavior of the different species of _____ in the world.
- physiology*
13. While physiology is interested in behavior, it is primarily concerned with the internal functions of the body. How the brain functions would thus not only be of interest to psychology, but would be a major concern of the science of _____.
- physiology*
14. So we can see that the sciences of psychology and _____ have much in common.
- organisms*
15. For one thing, psychologists and PHYSIOLOGISTS are both concerned with studying the behavior of _____.
- function*
16. For another, psychologists and physiologists are both concerned with how the internal organs of the body _____.
- physiologists*
17. The scientists who study physiology are called _____.

18. A study performed on the behavior of a species like *Paramecium caudatum* might be conducted by a *psychologist* or by a _____.

19. Likewise, a study of the functioning of the brain might be conducted by either a *physiologist* or by a *psychologist* (either order).

20. If a study is performed on the behavior of man, it might be conducted by a *physiologist* or by a *psychologist* (either order).

21. Other sciences are also interested in behavior. But the only sciences concerned with both behavior and internal functions are the sciences of *psychology* and *physiology* (either order).

22. Many factors influence the behavior of *organisms* _____.

23. One of these factors is the ENERGY that strikes the organism. Energy that strikes the organism may influence the *behavior* _____ of that organism.

24. Numerous types of *energy* _____ strike or impinge on organisms.

25. An organism's behavior is influenced by the nature of the *energy* _____ that IMPINGES ("im pĭnj'iz") on it.

26. The nature of the energy that strikes or *impinges* _____ on an organism is one factor that determines behavior.

27. When a certain "bit" of energy influences the *behavior* _____ of organisms we call that energy a STIMULUS.

28. Energy that impinges upon an organism is called a *stimulus* if that energy affects behavior.

29. Any energy that affects, produces, or modifies behavior is called a *stimulus*.

30. If energy that impinges on an organism does not activate the *organism* to behave in some way, then we could not call that energy a *stimulus*.

31. One example of energy that would not activate an organism is when that *energy* is extremely slight in intensity.

32. In this case, the energy is too "weak" to activate the organism and hence it could not be called a *stimulus*.

33. The plural for stimulus is *stimuli*. If a number of separate bits of energy impinge on an organism, we say that a number of different *organism* are impinging on that *organism*.

34. A light is a specific type of energy. If a light impinges on an organism and causes the organism to behave, we call that light a *stimulus*.

35. If an organism comes in contact with the type of energy that we call an "odor," then that odor is a *stimulus*, provided that it activates the organism.

36. Another example of a stimulus is when an intense sound strikes, or *impinges* on, an organism.

37. At any specific time, many, many, different *stimuli* are impinging on any given organism.

impinge 38. The sum total of all stimuli that could _____ on an organism is called that organism's ENVIRONMENT.

stimulus 39. A specific _____ is, then, part of an organism's environment.

environment 40. An organism is always surrounded by a large number of stimuli. The sum total of those stimuli constitute the organism's _____.

environment 41. A wide variety of stimuli from an organism's _____ are constantly impinging on the organism to produce different kinds of behavior.

environment 42. When a specific type of stimulus from an organism's _____ impinges on that organism, it causes a specific type of behavior.

stimulus 43. We can thus say that a given _____ which impinges on an organism, produces a specific kind of _____.

behavior 44. The specific type of _____ that results from a given stimulus is called a RESPONSE.

response 45. If a baby touches a hot stove, he will immediately withdraw his hand. Withdrawing the hand is an example of the kind of behavior that we call a _____.

stimulus 46. If an extremely bright light impinges on an organism's eye, the pupil of the eye will contract. The very bright light is an example of a _____ and the contraction of the pupil is an example of the kind of behavior that we call a _____.

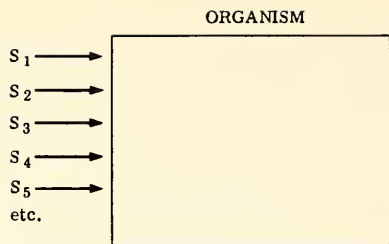


FIGURE 1

47. s_1 stands for one specific stimulus, s_2 stands for another stimulus, and so forth. Figure 1 shows that a large number of _____ are impinging on an organism.

48. All of the _____ that could impinge on an organism are called that organism's _____.

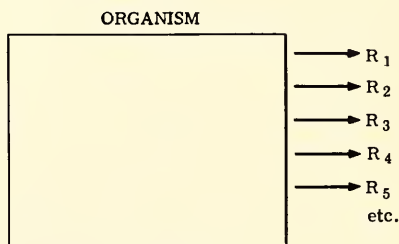


FIGURE 2

49. R_1 stands for a specific response, R_2 for another response, and so forth. Figure 2 shows that a large number of _____ are being made by an organism at any given time.

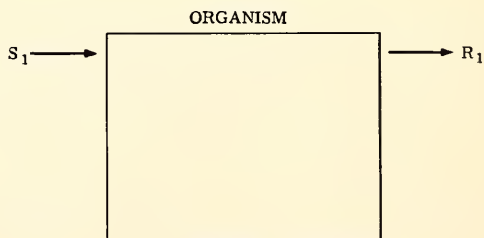


FIGURE 3

50. Figure 3 shows that when a specific _____ (s_1) impinges on an organism a specific _____ (R_1) results.

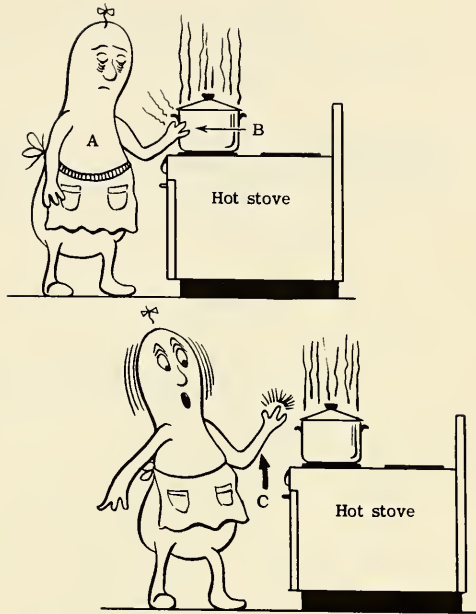


FIGURE 4

51. In the top of Figure 4 we see an organism touching a hot stove. In the bottom of Figure 4 we see him withdrawing his hand from the hot stove. In this figure, *organism* A is the _____, the heat *stimulus* B is the _____, and C, the withdrawal of the *response* hand from the hot stove, is the _____.

52. In Figures 1, 2, and 3 we have represented the *organism* as a "box." The inside of the box represents the inside of the _____ and includes a variety of organs such as the heart, brain, and ears.

53. Just as the environment and behavior of an *organism* are very complex, the inside of the _____ is also very complex.

54. The sciences of psychology and physiology are both concerned with how the internal organs FUNCTION to produce the kind of behavior we call a *response* _____.

- function* 55. We shall now see how some of the internal organs _____ in order for responses to occur.
- stimulus* 56. When a _____ impinges on an organism, it activates, or excites a specific type of organ that we call a RECEPTOR.
- stimulus* 57. The eye is an example of a RECEPTOR. A light flashing in a person's eye is a _____ that can excite that receptor.
- receptors* 58. The more highly developed organisms possess many different types of _____ that can be excited by stimuli.
- stimulus receptor* 59. A light is a specific type of _____ that EXCITES the _____ in the organism known as the eye.
- stimuli receptor* 60. Sounds are _____ that EXCITE the _____ known as the ear.
- stimulus excites* 61. An odor is the type of _____ that _____ the receptor known as the nose.
- environment receptors* 62. Many types of stimuli from an organism's _____ impinge on it to excite the various types of _____.
- stimulus receptor* 63. Tiny nerves are connected to all receptors. When a receptor is excited by a _____, the tiny nerve attached to the _____ is activated.
- receptor* 64. When a stimulus excites a _____, a NERVE IMPULSE is transmitted from the receptor and runs along the attached nerve.

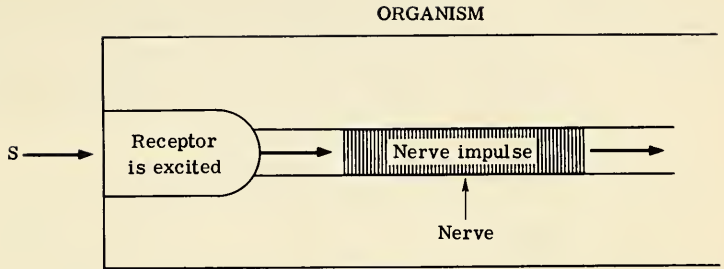


FIGURE 5

- stimulus* 65. In Figure 5 we see that when a _____ impinges on a receptor it causes that receptor to set off a _____ impulse that is carried along the nerve.
- nerve*
66. The excitation of a receptor sets off a nerve _____.
- impulse*
67. When a receptor is excited, the consequent active process in the nerve is called a _____.
- nerve impulse*
68. For the moment, a nerve impulse may be thought of as analogous to electricity. Electricity is conducted along wires—nerve impulses are _____ along tiny nerves.
- conducted*
69. Thus, when a receptor is excited, it causes a _____ to be conducted along a tiny nerve.
- nerve impulse*
70. Series of nerves that connect to receptors eventually enter the brain. Thus, the _____ generated by the receptors are conducted along a series of nerves to the brain.
- nerve impulses*
71. At any given time, many of an organism's receptors are being excited by many _____, and, therefore, many different nerve impulses are being conducted simultaneously to the _____.
- stimuli*
- brain*

72. For example, when a sound excites the ear, a light might also be striking the organism's eye. In this case, we note that two _____ *nerve impulses* _____ are being simultaneously conducted to the brain.

73. Up to this point we have seen that an *organism* _____, be it a man, a dog, or a paramecium, is constantly receiving a large number of *environment* stimuli from his _____.

impinge 74. When these different stimuli _____
receptors on the organism, its _____ are excited.

excited/activated 75. When the organism's receptors are _____,
nerve impulses they generate _____.

76. The nerve impulses that are generated by receptors are then transmitted along tiny _____ to the _____.

brain 77. After nerve impulses arrive in the _____, they eventually leave it and are transmitted along series of nerves to effectors.

78. There are two principal kinds of effectors: muscles are effectors, and glands are _____.

nerve impulses 79. Because many _____ are being conducted into the brain at any given time, many nerve impulses leave the brain at any given time and run to _____.

80. Nerve impulses that leave the brain run to a number of different effectors.

81. The body contains a very large number of muscles and glands. All of these _____ and _____ are effectors.

82. When one thinks about the very large number of muscles in the arms, legs, throat, etc., one begins to realize how very many _____, of the muscle type, the body contains.

effectors

83. We have said that muscles are effectors and that _____ are effectors.

glands

84. One kind of gland is the sweat gland. The _____ is a specific type of effector.

sweat gland

85. The tear gland, which produces tears in the eyes, is another example of an _____.

effector

86. When a stimulus from an organism's environment impinges on one of its _____ a _____ is generated that travels along tiny _____ to the _____.

receptors

nerve impulse

nerves; brain

87. The nerve impulse, then, eventually leaves the brain and typically arrives at one of two types of _____: _____ and _____.

effectors; muscles

glands

88. When a _____ arrives at an effector, that effector is ACTIVATED.

nerve impulse

89. Although there are a number of different kinds of muscles and glands, any of these effectors may be _____ if they are stimulated by a nerve impulse.

activated

90. When a nerve impulse leaves the brain and activates an _____, we say that a RESPONSE occurs.

effector

91. The activation of an effector results in a _____.

response

92. Responses occur in different ways for glands and
muscles _____.
93. A muscle CONTRACTS when it is activated by a
nerve impulse _____.
94. When a muscle contracts, we say that a
response _____ occurs.
95. A nerve impulse that arrives at a muscle produces a _____ by causing the muscle to contract.
response
96. Another way of saying this is that the nerve impulse that arrives at a muscle is an internal stimulus. The nerve impulse thus stimulates the muscle, and the muscle _____.
contracts
97. When a nerve impulse stimulates a muscle, the muscle _____ and a response occurs.
contracts
98. When a man makes a response, such as opening a door, we know that the muscles in his arms are _____.
contracting
99. When a muscle contracts, a _____ occurs.
response
100. All muscles contract when stimulated by _____, but this is not the case with glands.
nerve impulses
101. Each gland secretes a product. For example, the tear _____ secrete the product that we call tears.
glands
102. The product secreted when the sweat glands are activated is called _____.
sweat
103. Whereas muscles contract when stimulated, various products are secreted when _____ are stimulated.
glands

104. Essentially, an organism can make a response in two ways. When his muscles contract, or when his glands secrete a product, we say that a _____ occurs.

105. We can thus see that when a stimulus excites a receptor that receptor sets off a nerve impulse which is _____ along nerves to the brain.

106. Eventually the nerve impulse leaves the brain and stimulates an _____.

107. When the effector stimulated is a muscle, it _____, but if the effector stimulated is a _____, a product is secreted.

108. When either a muscle contracts, or a gland secretes a product, a _____ occurs.

109. To integrate what we have said so far, let us study Figure 6.

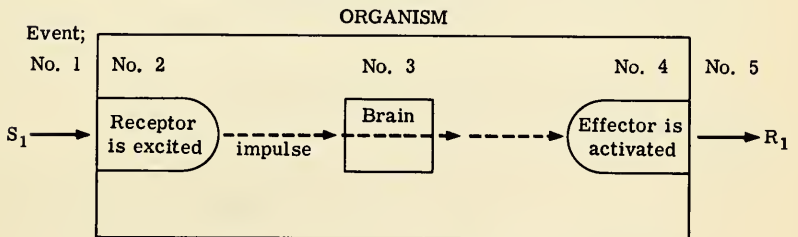


FIGURE 6

110. In Figure 6 we see _____ events labeled.

111. Event No. 1 is a _____ impinging on an organism.

112. Event No. 2 indicates that the stimulus excites a _____ to set off a nerve impulse.

113. Event No. 3 shows the _____ being conducted from the receptor through the brain and then finally to an _____.

- activates* 114. Event No. 4 shows that the nerve impulse _____ an effector.
- response* 115. Event No. 5 indicates the resulting _____.
116. To briefly summarize, let us note that when
environment a stimulus from the _____ im-
organism; receptor pinges on an _____, a _____
is excited.
- nerve* 117. The excitation of a receptor sets off a _____
impulse _____ that is conducted along a series of
brain nerves into the _____.
- conducted* 118. The nerve impulse eventually leaves the brain
effector and is _____ along nerves to an
_____.
119. When the nerve impulse arrives at an effector,
that effector is activated. If the effector is a muscle, it
contracts; gland _____; but if the effector is a _____,
it secretes its product.
- response* 120. The activation of an effector, be it a gland or a
muscle, constitutes a _____.
- impinges* 121. Now we want to find out more specifically what
response happens inside an organism when a specific stimulus
_____ on it and causes it to make a
specific _____.
- receptors* 122. There are three general categories of organs,
inside an organism, that we want to study. These are:
(1) organs such as the eye and ear, called
_____; (2) the collections of nerves
that make up the nervous systems, including the brain,
effectors and (3) the different types of _____
(muscles and glands) that produce responses.

RECEPTORS

Section II: The Ear

impinge 123. We have said that an organism's environment consists of numerous types of energy that _____ on that organism.

stimulus 124. When energy from the environment excites a receptor, we call that energy a _____.

sense 125. The lay person typically believes that man possesses five "senses." To "explain" certain mystical phenomena, he then, sometimes, postulates the existence of a sixth _____.

sense 126. Actually, however, man possesses more than six senses, with a unique type of receptor for each _____.

environment 127. Each receptor is especially sensitive to a particular type of energy that comes from the organism's _____.

ear 128. One type of energy that impinges on an organism is what we call SOUND WAVES. The receptor that is particularly sensitive to sound waves is the _____.

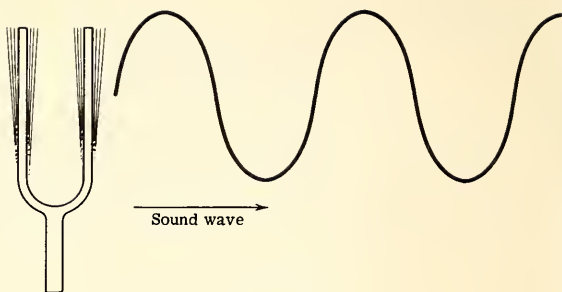


FIGURE 7

129. When an object, such as a tuning fork—which is part of a person’s environment—is struck, it vibrates and typically sets off SOUND WAVES. Figure 7 shows a vibrating tuning fork that is sending _____ through the air.

sound waves

130. Usually there are many vibrating objects (auto horns, school bells, etc.) in a person’s environment. These vibrating objects send numerous _____ through the air.

sound waves

131. The _____ from the many vibrating objects, then, typically impinge on a person’s ear.

sound waves

132. When a sound wave enters a person’s ear, that receptor is normally excited, whereupon a _____ in the attached nerve is started.

nerve impulse

133. The ear, however, is not excited by all of the sound waves that _____ on it.

impinge

134. There are two reasons for this. One reason is that not all of the _____ are “strong” or “loud” (intense) enough to excite the _____ called the ear.

sound waves

receptor

135. That is, a _____ that impinges on the ear must be of sufficient intensity (sufficiently “strong”) before the ear can be _____.

sound wave

excited/activated

sound wave 136. If a _____ is of extremely small intensity, then it may be too weak to excite the ear (it can't be "heard").

excited/activated 137. The intensity of a sound wave determines whether or not the receptor will be _____.

intensity 138. If the sound wave is very weak, then we say that it is of small _____.

intensity 139. But if the sound wave is quite strong, then we say that its _____ is great.

sound wave 140. The minimum (least) intensity of a _____ necessary to excite the ear is called the ABSOLUTE THRESHOLD of the ear.

threshold 141. The concept of the ABSOLUTE THRESHOLD is very important. It applies to all of the receptors. In the case of the ear, if the sound stimulus is of sufficiently weak intensity, that stimulus is said to be below the absolute _____.

absolute 142. If a sound wave is of rather great intensity (it can be "heard"), then it is above the _____ threshold.

absolute threshold 143. The minimum intensity of a sound wave necessary to excite the ear is the _____ of the ear.

environment 144. We previously saw that a stimulus consists of energy from an organism's _____.

energy 145. The amount of stimulus ENERGY determines the intensity of the stimulus. Hence, the intensity of a sound wave is determined by the amount of _____ that it carries.

excite/activate 146. The minimum stimulus energy, necessary to _____ a receptor, is called the absolute threshold.

absolute threshold

147. The concept of the absolute threshold applies to all receptors. The minimum intensity of a light stimulus necessary to excite the eye is called the _____ of the eye.

absolute threshold

148. The minimum stimulus energy of an odor, necessary to excite the nose, is the _____ of that receptor.

excite/activate

149. If a sound wave is extremely weak, it is below the absolute threshold of the ear and, thus, will not _____ the ear.

not

150. Another reason that a sound wave might _____ excite the ear is that the ear is not capable of responding to all sound waves.

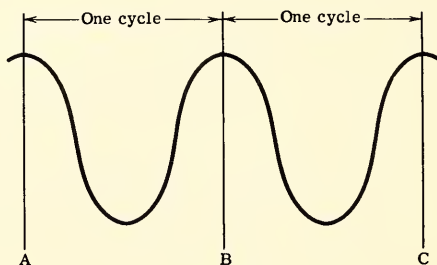


FIGURE 8

cycle

151. To understand this, let us note that, in Figure 8, a sound wave is divided into CYCLES. The part of the sound wave between lines A and B indicates one _____.

cycles sound wave

152. One can count the number of _____ of a _____ that occur during any given period of time.

cycles

153. The FREQUENCY of a sound wave is the number of cycles that occur in one second. If one counts 1500 cycles occurring in one second, then one can say that the frequency of the sound wave is 1500 _____ PER SECOND.

154. If 20 cycles occur in one second, then the frequency of the sound wave is 20 cycles _____
per second _____.

155. If 20,000 cycles occur in one second, then the FREQUENCY of the sound wave is 20,000 _____
cycles per second _____.

156. The human ear is generally capable of responding to any sound wave with a _____
frequency between 20 cycles per second and about 20,000
cycles per second _____.

157. Is the human ear capable of responding to a sound wave that has a frequency of 3 cycles per second? _____
 No

158. Nor is the human ear capable of responding to a sound wave that has a _____ of 40,000 cycles per second.
frequency

159. We can thus see that the range of frequencies of sound (auditory) stimuli to which the ear can respond is restricted. That is, the ear cannot respond to an unlimited range of _____
frequencies of sound waves.

160. The range of frequencies to which the ear is capable of responding is different for the different species. The ear of the dog, for instance, is capable of being excited by auditory (sound) stimuli of greater _____ than is the ear of man.
frequency

161. The dog whistle is based on this fact. The dog whistle emits sound waves with frequencies greater than 20,000 _____.
cycles per second

162. Since the dog whistle emits sound waves with frequencies _____ than 20,000 cycles per second, man cannot "hear" it.
greater

20,000 163. But since the dog's ear does respond to frequencies above _____ cycles per second, a dog can be trained to approach us at the sound of a dog whistle.

20,000 164. The human ear is not capable of responding to auditory stimuli below 20 cycles per second or above _____ cycles per second.

frequency 165. The human ear will normally respond to its particular type of environmental energy provided (1) that the _____ of the sound wave falls within the range of 20 to 20,000 cycles per second; and (2) that the intensity of the sound wave is above the absolute threshold _____.

20
20,000 166. Consider a sound wave that is above the absolute threshold and that is within the range of man's ear: that is, it has a frequency between _____ and _____ cycles per second.

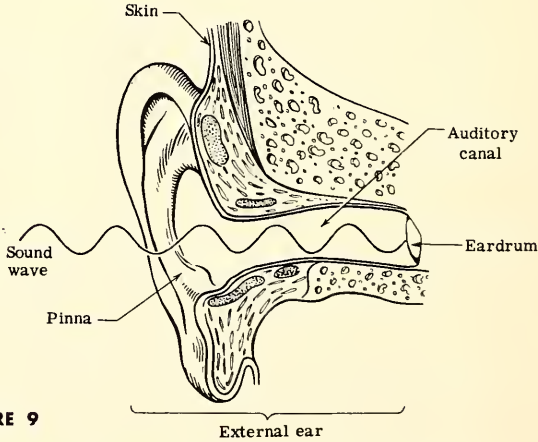


FIGURE 9

pinna 167. Study Figure 9, and note how such a sound wave enters the ear. It first goes through the external ear or PINNA. The function of the external ear, or _____ is to collect sounds from the environment.

pinna 168. Sounds that are collected from the environment by the _____ then travel through the auditory canal.

169. As the sound waves travel through the _____ canal, they strike the eardrum.
170. Sound waves are collected by the _____, then travel through the _____ until they come to the eardrum.
171. The eardrum is a very thin MEMBRANE (a thin, soft sheet of tissue) which is stretched across the end of the _____.
172. The varying pressure of the sound wave causes the membrane, called the _____, to vibrate (move back and forth).
173. When an auditory stimulus is conducted through the pinna, it is transmitted through the auditory canal and strikes the _____ called the eardrum.
174. When an auditory stimulus strikes the eardrum, the eardrum _____ (moves back and forth).

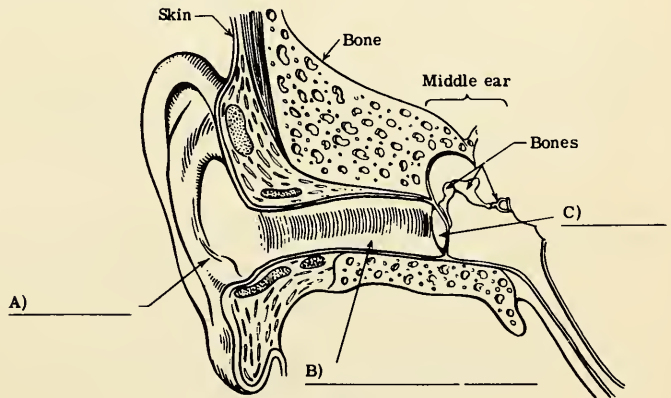


FIGURE 10

175. Identify the parts by filling in the blanks provided in Figure 10.

- A. Pinna
B. Auditory canal
C. Eardrum

176. Figure 10 represents the middle ear. It shows that one of three small bones is attached to the *eardrum* _____.
177. When the eardrum vibrates, the vibration is carried through the three small _____ of the *bones* middle ear.
178. It can be seen in Figure 10 that the auditory stimulus is conducted through the middle _____ by means of the vibrations carried along in the three *ear* small bones.
179. The three small _____ of the middle *bones* ear are called the OSSICLES (*ô's'ə kəlz*).
180. The vibrations are conducted through the middle ear by means of three small bones called the *ossicles* _____.
181. Sound waves enter the external ear, or *pinna; auditory* _____, travel along the _____, and then strike the eardrum. *canal*
182. When the sound waves strike the eardrum, the eardrum vibrates which, in turn, causes the ossicles also to _____.
183. The vibration transmitted from the eardrum to the ossicles allows the sound to be conducted through the middle _____.
184. The ossicles are in the _____ ear.
185. The ossicles are attached to the external ear at the eardrum and to the part of the inner _____ called the COCHLEA (*kök'li ə*).
- ear*

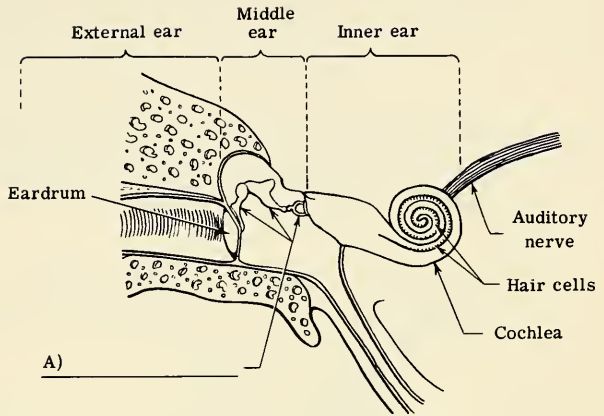


FIGURE 11

- A. *Ossicles* 186. Fill in the blank for Figure 11.
- ossicles* 187. In Figure 11 we see that the three small bones called the _____ are attached to the cochlea.
- middle ossicles* 188. When the eardrum vibrates, the auditory stimulus is conducted through the _____ ear by means of the three bones called the _____ until the vibrations reach the cochlea.
- cochlea* 189. The word COCHLEA comes from the Greek word meaning “snail shell.” This structure is called the _____ because it is spiraled like the shell of a snail.
- cochlea* 190. When the ossicles of the middle ear vibrate, the vibrations are transmitted to the _____.
- inner middle* 191. The cochlea is located in the _____ ear and receives vibrations from the ossicles of the _____ ear.
- cochlea* 192. The inside of the structure that looks like a snail shell, called the _____, contains a fluid.

cochlea; inner 193. The _____ is a part of the _____ ear and contains fluid.

ossicles; vibrations 194. When the cochlea receives vibrations from the _____, those _____ cause changes in the pressure of the fluid contained in the cochlea.

fluid 195. The cochlea contains _____. The
cochlea _____ also contains tiny sensory cells called
HAIR CELLS.

cochlea 196. When the ossicles transmit vibrations to the fluid inside the _____, variations in pressure of that fluid occur.

fluid 197. The variation of the pressure of the _____ inside the cochlea stimulates the tiny hair cells.

pressure 198. The variation of the _____ of the
hair cells fluid inside the cochlea stimulates the tiny sensory cells called _____.

hair 199. The change of pressure of the fluid inside the
cells cochlea exerts vibratory pressure on the _____.

✓
auditory 200. When a sound wave is picked up by the pinna,
canal; eardrum it is transmitted along the _____ until it strikes the _____.

middle 201. The vibrations are then transmitted from the external ear, through the _____ ear, by means of the ossicles.

inner 202. The cochlea, located in the _____ ear, then receives those vibrations.

fluid 203. Once the cochlea receives vibrations, changes in the pressure of the _____ inside it occur.

pressure 204. These changes in the _____ of
hair cells the fluid stimulate the tiny _____
 inside the cochlea.

nerves 205. Numerous tiny nerves are attached to the hair
 cells. These tiny _____ group together to form
 part of a major nerve called the auditory nerve.



FIGURE 12

206. Identify the structures in Figure 12 by filling
 in the blanks.
 A. Ossicles
 B. Cochlea

nerve 207. In Figure 12 we see that the auditory _____
 runs from the hair cells of the cochlea to the brain.

inner 208. The auditory nerve is a major nerve that runs
brain from the cochlea, located in the _____ ear, to
 the _____.

auditory; brain 209. When the hair cells are stimulated, they set
 off nerve impulses that are transmitted along the
 _____ nerve to the _____.

auditory nerve 210. The stimulation of the hair cells sets off nerve
 impulses that are transmitted to the brain by means of
 the _____.

211. Let us now summarize what we have learned by
 stating the events that occur in the receipt of an
 auditory stimulus.

wave
auditory 212. Event No. 1: The vibration of a stimulus object produces a stimulus in the form of a sound _____. This sound wave is called a sound or _____ stimulus.

ear 213. Event No. 2: That sound wave is transmitted through the air and is collected by the external _____ or PINNA.

pinna 214. Event No. 3: Once the _____ collects the sound wave, it transmits vibrations through the auditory canal.

auditory canal 215. Event No. 4: When the auditory stimulus is collected by the pinna and transmitted through the _____, it strikes the eardrum.

eardrum 216. Event No. 5: When the sound wave strikes the _____ it causes that membrane to vibrate. The sound wave can only cause the membrane to vibrate sufficiently to transmit the sound if two things happen: (1) if the frequency of the sound wave is between 20 and 20,000 _____; and (2) if the intensity of the sound wave is above the _____ of the ear.

cycles per second
absolute threshold

auditory 217. If the frequency of the sound wave is not between 20 and 20,000 cycles per second, or if its intensity is below the absolute threshold, then the sound wave cannot be called an _____ stimulus for the human ear.

218. Event No. 6: When the eardrum vibrates, it causes the three bones of the _____ ear called the _____ to vibrate.

*middle
ossicles*

219. Event No. 7: The auditory stimulus is thus transmitted through the middle ear as a series of _____ of the ossicles.

vibrations

220. Event No. 8: These ossicles are attached to the part of the _____ ear known as the cochlea. The vibrations of the ossicles are thus transmitted to the _____.

*inner
cochlea*

221. Event No. 9: The vibrations received by the cochlea produce changes in the pressure of the _____ inside it.

fluid

222. Event No. 10: The change of pressure in the fluid of the _____ is transmitted to the hair cells.

cochlea

223. Event No. 11: When the pressure of the fluid inside the cochlea changes, it stimulates the tiny sense cells called the _____.

hair cells

224. Event No. 12: When the hair cells are stimulated, they set off nerve impulses that are conducted along the tiny _____ that are attached to them.

nerves

225. Event No. 13: When the hair cells are stimulated, the nerve impulses, thereby produced, are conducted along the group of tiny nerves that form the major nerve called the _____.

auditory nerve

226. Event No. 14: The auditory nerve then conducts the nerve impulses to the _____.

brain

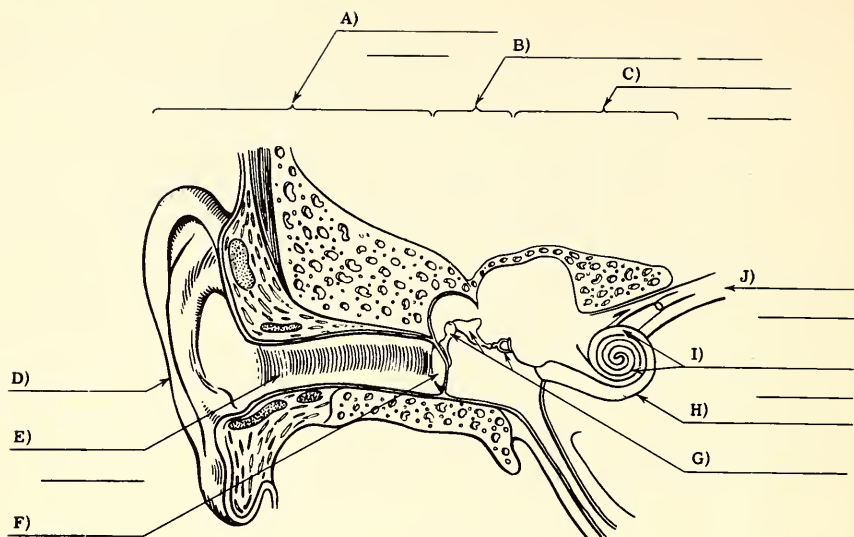


FIGURE 13

227. In Figure 13, write in the parts of the ear, in the blanks provided.

- A. *External Ear*
- B. *Middle Ear*
- C. *Inner Ear*
- D. *Pinna*
- E. *Auditory Canal*
- F. *Eardrum*
- G. *Ossicles*
- H. *Cochlea*
- I. *Hair Cells*
- J. *Auditory Nerve*

228. Without looking at the preceding discussion, draw a diagram of the parts of the external, the middle, and the inner ear, concluding with the auditory nerve that runs to the brain. State each step that occurs, from the point at which a vibrating object sends off a sound wave, to the point where a nerve impulse is transmitted to the brain. Be sure to label each part of the ear. Then check your diagram and steps for accuracy against the preceding discussion. (Standard size notebook paper may be used for all drawings that appear in this book.)

RECEPTORS

Section III: The Eye

auditory 229. We have just seen how the type of energy that we call an _____ stimulus leaves a vibrating stimulus object, impinges on the ear, and sets off a nerve impulse that runs to the _____.

brain

eye 230. In like manner, we shall now trace the process by which the type of environmental energy, that we call a visual stimulus, leaves a stimulus object and sets off a nerve impulse that runs from the receptor, called the _____, to the brain.

stimulus 231. Some stimulus objects emit what we call **RADIANT** (rā'dī ənt) **ENERGY**. A light bulb is an example of a _____ object that emits radiant energy.

energy 232. Consider the various stimulus objects, in a person's environment, that emit **RADIANT ENERGY**. A stimulus object, such as a light bulb, itself produces the radiant _____ that it emits.

radiant 233. Other stimulus objects, however, do not produce radiant energy, but rather they reflect _____ energy coming from other sources.

receptor 234. For example, a light bulb in a room produces radiant energy that strikes the wall. That radiant energy is then reflected from the wall and is transmitted to the organism's visual _____ that we call the eye.

235. Another example of a stimulus object that itself
radiant energy emits _____, is a lighted
 match.

236. A desk is an example of a stimulus object that
radiant energy reflects, rather than emits, _____.

237. One way of characterizing radiant energy is in
 terms of waves. In the case of auditory stimuli, we
waves talked about sound WAVES; in the case of visual stimuli,
 we shall talk about light _____.

238. A stimulus object, such as a light bulb, gives off
waves radiant energy that can be described in terms of
 light _____.

239. Light waves are produced by stimulus objects
radiant that give off _____ energy.

240. When a stimulus object gives off _____
radiant energy _____, light waves are produced.

241. The radiant energy given off by visual stimuli
light produces _____ waves of a much greater fre-
 quency than is the case for sound waves.

242. Because the frequency of light waves is greater
light waves than the frequency of sound waves, _____
 _____ travel much faster than do sound waves.

243. To be more precise, sound waves travel about
light waves 1,100 feet per second, whereas _____
 _____ travel about 186,000 miles per
 second.

244. We previously saw that the human ear cannot
 be excited by all frequencies of sound waves. In like
 manner, all frequencies of radiant energy cannot be
eye "picked up" by the human _____.

245. While the eye can be excited by certain frequencies of radiant energy, it cannot be excited by other _____.

frequencies

246. Infrared rays are an example of a frequency that is too slow to activate the human _____.

eye

247. Radar and radio waves are other examples of _____ of radiant energy that are too slow to _____ the human eye.

frequencies

excite/activate

248. Ultraviolet rays, x-rays, and gamma rays are frequencies of _____ energy that are too fast to _____ the human eye.

radiant

excite/activate

249. The frequencies that can _____ the eye are called the VISIBLE SPECTRUM.

excite

250. The visual stimuli to which we respond are the frequencies of radiant _____ which constitute the visible spectrum.

energy

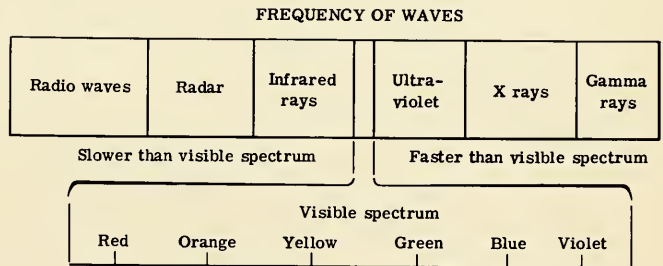


FIGURE 14

251. In Figure 14, we can see a representation of various frequencies. Note that gamma rays, x-rays, and ultraviolet rays have a frequency greater than that of the visible _____.

spectrum

252. On the other hand, infrared rays, radar waves, and radio waves are lower in frequency than the _____.

visible spectrum

- visible spectrum* 253. We cannot see infrared rays because their frequency is less than that of the _____.
- frequencies visible spectrum* 254. The human eye can only be excited by _____ of radiant energy that fall within the _____.
- excite/activate* 255. Frequencies of radiant energy that fall above or below the visible spectrum cannot _____ the human eye.
- visible spectrum* 256. A light wave is radiant energy that has a frequency in the region of the _____.
- visible spectrum* 257. The visible spectrum can be divided into frequencies for the different colors. For example, one particular frequency within the _____ is that for red light.
- frequencies visible spectrum* 258. A frequency of light waves greater than that for red is the frequency for blue light. The _____ for blue and red light both fall within the _____.

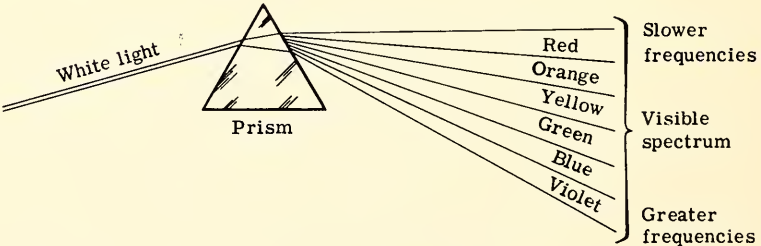


FIGURE 15

- greater/faster/higher* 259. In Figure 15, we see the colors that constitute the visible spectrum. Note that the frequency of blue light is _____ than the frequency of red light.
- wave* 260. A light _____ may be a VISUAL STIMULUS.

261. Remember that visual stimulus objects give off _____ energy which travels through the air in the form of _____.

262. Light bulbs and the sun are examples of stimulus objects that emit _____ in the form of light waves.

263. If a light wave impinges on a person's eye and excites the eye, we call that light wave a visual _____.

264. Visual stimuli are light waves that have frequencies that fall within the _____.

265. A visual stimulus can come from any object that we can see. While some objects themselves emit _____ in the form of light waves, other objects REFLECT it.

266. A book or a picture are examples of objects that do not emit radiant energy, but rather they _____ it from other sources.

267. The eye can thus be excited by light waves that are either emitted or _____ from stimulus objects.

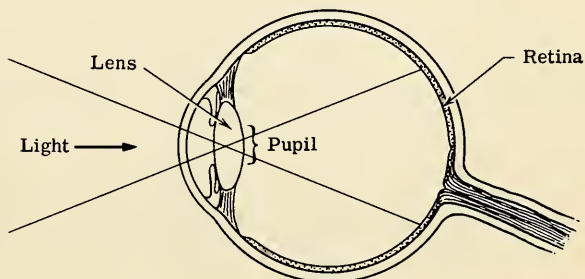


FIGURE 16

268. In Figure 16, we see a representation of light entering the human _____.

269. As shown in Figure 16, the light first passes through the PUPIL and LENS. The light finally falls on the _____ of the eye.

retina (rĕt'ə nə)

270. The lens is supported by a group of muscles. As these muscles contract and relax, the PUPIL opens and _____.

closes

271. The pupil is the black center that we see when we look in a person's eye. The _____ is simply an opening that changes in size to admit smaller and larger amounts of light.

pupil

272. As varying amounts of _____ enter the eye, the opening that we call the _____ changes in size.

*light
pupil*

273. The opening in the eye, through which light travels, is called the _____.

pupil

274. The lens of the eye is similar in function to the lens of a camera. The function of the lens of the eye is to focus the image of a _____ object onto the RETINA.

stimulus

275. As the muscles contract and relax, the LENS changes its shape. By changing its shape, the _____ assures that a sharp image of the stimulus object falls on the _____.

*lens
retina*

276. Hence, when we look at a stimulus object, a picture or image of it falls on the _____ of the eye.

retina

277. Now let us look at the retina of the eye in a little more detail. The _____ covers most of the inside of the eye.

retina

278. The image of a stimulus object passes through the lens and falls on the inside of the eye that we call the _____.

retina

- environment* 279. As the intensity of light that comes from an organism's _____ changes, the muscles of a person's eye change.
- lens* 280. Recall that as the muscles of a person's eye contract and relax, the shape of the lens changes. These modifications in the shape of the _____ produce a sharp image of the stimulus object on the
- retina* _____.
- lens* 281. When the lens changes its shape, it focuses the stimulus object. The reason that a sharp image falls on the retina of the eye is because the _____ focuses it.
- focus* 282. The function of the lens is to _____ a stimulus object so that a sharp image of it will fall on the retina.
- focus* 283. If the lens did not _____ the stimulus object, the image on the retina would be fuzzy rather than sharp and clear.
- radiant energy* 284. Some stimulus objects, in a person's environment, themselves emit _____ in the form of light waves.
- reflect* 285. Other stimulus objects, however, do not emit radiant energy, but rather they _____ it from other sources.
- excite* 286. In either case these light waves are visual stimuli if they impinge on an organism and _____ that organism's eye.
- visible spectrum* 287. All visual stimuli have frequencies that fall within the _____.
- frequency* 288. The color of the stimulus object that the person sees depends on the _____ of the light waves that come from it.

frequency 289. For example, if the frequency is quite slow, the person may see red. Light waves from blue objects, however, have a greater or higher _____ than do those from red objects.

pupil 290. When a light wave first enters a person's eye, it goes through the lens and the black center called the _____.

focus 291. The function of the lens is to _____ the stimulus object so that a sharp image will fall on the _____.

retina 292. It is possible to actually look inside a person's eye and see the image of a stimulus object on the person's _____.

retina 293. The retina of the eye contains two kinds of tiny cells called RODS and CONES. There are a very large number of rods and cones in the _____ of the eye.

retina 294. Just to give you a rough idea, it has been estimated that there are approximately 120,000,000 rods and 6,500,000 cones in the _____ of the human eye.

rods 295. Rods and cones are cells contained in the retina. These cells are called _____ and _____ because of their shape.

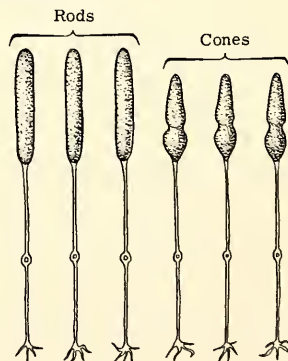


FIGURE 17

cones 296. As you can see in Figure 17, rods are cylindrical in shape whereas _____ are rather tapered.

297. Rods and cones are typically both excited when an image of a stimulus object falls on the retina.

298. Rods, however, are used in "black-white vision," whereas cones are used in "color vision."

299. You can always remember this difference if you note that the first two letters of "cones" and "color" are the same. Hence, rods are used in black-white vision, whereas cones; color are used in vision.

300. For example, if you are looking at a colored object, the cones are the cells of the retina that are excited.

301. Because they are used in black-white vision, rods are the cells that function at night-time.

302. Thus, if a person looks at a stimulus object at night, his rods; cones are excited, but his are not excited.

303. The old saying "at night all cats are gray" illustrates this point. That is, even a yellow cat would look gray at night because this stimulus object would cones not excite the of the retina.

304. Connected to the rods and cones are two other types of cells in the retina, of interest to us. These are called bipolar cells and ganglion cells.

305. The cones and rods are at the bottom or back of the retina.

306. Just above (in front of) the layer of the retina that contains rods and cones, one finds the BIPOLAR CELLS.

307. The bipolar cells are connected to the rods and cones.

308. The type of cell that is connected to the rods and cones is called the bipolar _____.

309. Rods and cones are in the bottom layer of the retina. Just above them are _____ cells.

310. The name of the cell that is connected to the rods and cones is the _____.

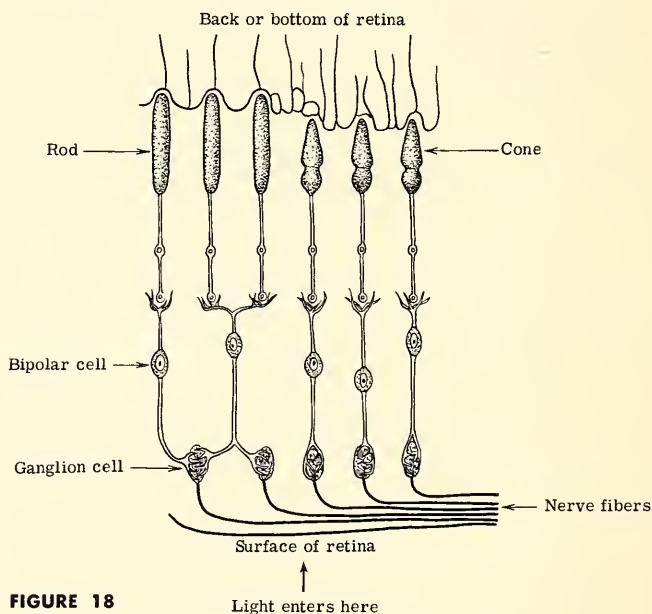


FIGURE 18

311. As can be seen in Figure 18, the bipolar cell is connected to another type of cell called the GANGLION CELL. For our present purposes, the bipolar _____ may be thought of as simply a link in a chain.

312. The bipolar cell is connected to the _____ cell.

313. Rods and cones are connected to _____ which, in turn, are connected to ganglion cells.

314. The name of the cell that is connected to the bipolar cell is the _____.

315. As can be seen in Figure 18, the end of the _____ cell is a tiny nerve fiber which can conduct a nerve impulse.
- ganglion*
316. We can thus see that the retina contains three layers of cells. At the bottom one finds _____ and _____.
- rods*
cones
317. The next layer contains _____ that connect to the rods and cones.
- bipolar*
cells
318. And in the surface or top layer, connected to the bipolar cells, one finds _____.
- ganglion*
cells
319. The end of each ganglion cell is a tiny _____ fiber that can conduct a nerve impulse.
- nerve*
320. Consider that light waves from an object pass through the pupil and lens, thus projecting an image of the object on the surface of the _____.
- retina*
321. The radiant energy of the light waves that form the image is transmitted to the bottom or back of the retina where it stimulates rods and _____.
- cones*
322. When the radiant energy from a stimulus object reaches the back of the _____, a CHEMICAL reaction occurs.
- retina*
323. Light falling on the retina sets off a chemical reaction that stimulates _____ and cones.
- rods*
324. When light waves from a stimulus object fall on the retina to form an image, the radiant energy of those light waves produces a _____ reaction.
- chemical*
325. That chemical _____ then excites the _____ and _____.
- reaction*
rods; cones

- excited/activated* 326. When the rods and cones are _____, a nerve impulse is set off.
- impulse cells* 327. This nerve _____ is then transmitted to the bipolar _____.
- bipolar; nerve impulses* 328. The _____ cells receive _____ that are set off by the rods and cones.
- bipolar cells* 329. When a nerve impulse is set off by the rods and cones, that nerve impulse is received by the _____.
- bipolar* 330. When a nerve impulse is generated by the rods and cones, it is received by the _____ cells and is then transmitted to the ganglion cells.
- ganglion* 331. The bipolar cells transmit nerve impulses to the _____ cells.
- ganglion* 332. You will recall that the ends of the ganglion cells are tiny nerve fibers. These nerve fibers of the _____ cells make up the OPTIC NERVE.
- nerve* 333. The nerve fibers that are the end of the ganglion cells form a major nerve called the optic _____.
- optic* 334. The major nerve called the _____ nerve runs from the eye to the brain.

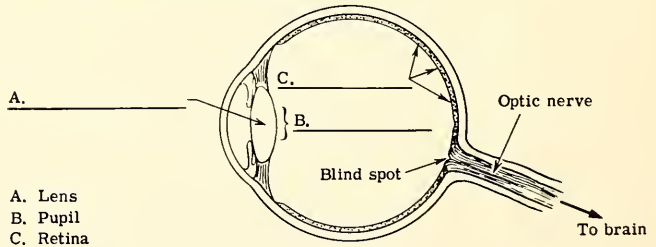


FIGURE 19

- A. Lens*
B. Pupil
C. Retina
335. Write in the parts of the eye in the blanks provided.

- optic brain* 336. Figure 19 shows the _____ nerve leaving the eye and running to the _____.
- nerve impulse* 337. When a ganglion cell receives a nerve impulse, that _____ is transmitted along the nerve fibers of the ganglion cell that compose the optic nerve.
- optic nerve* 338. In this way the nerve impulse is transmitted along the _____ to the brain.
- ganglion* 339. The optic nerve is made up of nerve fibers of the _____ cells.
- optic nerve* 340. The nerve that transmits nerve impulses from the eye to the brain is called the _____.
- spot* 341. Note the blind spot in Figure 19. The blind _____ is a place in the retina where the tiny nerve fibers of the ganglion cells congregate to form the _____ nerve.
- optic*
- blind* 342. Because the _____ spot consists exclusively of nerve fibers, it does not contain cones and _____.
- rods*
- impulse* 343. Since there are no rods and cones in the blind spot of the retina, an image of a stimulus object falling at that place cannot set off a nerve _____.
- blind spot* 344. Hence, we cannot see the part of a stimulus object that falls on the _____.
- blind spot* 345. Kings used to use this fact for their enjoyment: they would close one eye and look at the court jester in such a way that the jester's head would fall on the _____.

346. If the king liked the way the jester looked without a head, he would have the jester beheaded. With a little practice, you can note that a part of an object cannot be seen if you cause its image to fall on the _____ of one of your eyes.
- blind spot*
347. We can thus see that the following events occur in the receipt of a visual _____.
- stimulus*
348. Event No. 1: A stimulus object either emits or reflects _____ energy.
- radiant*
349. Event No. 2: The radiant energy is then transmitted to the eye in the form of _____ waves.
- light*
350. Event No. 3: The light waves first pass through the _____ and lens of the eye.
- pupil*
351. Event No. 4: As the light rays pass through it, they are focused by the _____ of the eye.
- lens*
352. Event No. 5: The lens causes a sharp image of the stimulus object to fall on the _____ of the eye.
- retina*
353. Event No. 6: When the light rays form an image on the _____ of the eye, the tiny cells called the _____ and _____ are stimulated.
- retina*
rods; cones
354. Event No. 7: When the rods and cones are stimulated, they set off _____.
- nerve impulses*
355. Event No. 8: The nerve impulses set off by the _____ and _____ are transmitted to the bipolar cells.
- rods; cones*
356. Event No. 9: The nerve impulse is then conducted along the _____ and is thus transmitted to the ganglion cells.
- bipolar cells*

ganglion
optic
brain

357. Event No. 10: When the nerve impulse is received by the _____ cells, that nerve impulse is conducted along the _____ nerve to the _____.

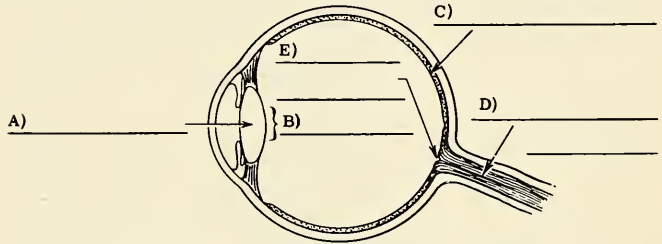


FIGURE 20

358. Label each part of the eye in the blanks provided in Figure 20.

- A. Lens
- B. Pupil
- C. Retina
- D. Optic nerve
- E. Blind spot

359. Without looking at the preceding discussion, draw a diagram of light entering the eye, and specify each event that occurs between the point at which the light enters the eye and the point at which the resulting nerve impulse leaves the eye to be conducted to the brain. After you have done this, go back and check yourself against the material you have just read.

RECEPTORS

Section IV: Olfaction

- smell* 360. We have briefly seen how the eye and ear work. Let us now consider how the receptor cells in the nose respond to a SMELL. The nose contains receptor cells that are particularly sensitive to a _____.
- smell* 361. OLFACTION is the technical term for the sense of _____.
- olfaction* 362. When we want to talk about the sense of smell, we will usually use the term _____.
- stimuli* 363. When talking about smell, we will refer to OLFACTORY stimuli instead of smell _____.
- olfactory* 364. Thus, we say that the nose is particularly sensitive to _____ stimuli.
- olfactory* 365. The type of stimulus that excites the nose is the _____ stimulus.
- Olfactory* 366. _____ stimuli are odors.
- odors* 367. A number of stimulus objects in our environment give off ODORS. These _____ are potential olfactory stimuli.
- odors* 368. Odors are in a gaseous state. More particularly these _____ are a mixture of air and the MOLECULES (mŏl'ə kūl) that come from the stimulus objects.
- molecule* 369. For our present purposes, we may think of MOLECULES as tiny particles. A _____ is a tiny particle.

molecules 370. Stimulus objects consist of MOLECULES. Some of these _____ leave the stimulus objects to enter the air.

molecules 371. When a stimulus object, such as a cup of coffee, emits molecules, these _____ mix with the air to create an ODOR.

odor 372. When molecules from an object mix with air, an _____ is created.

environment 373. There are numerous stimulus objects in our _____ that give off molecules.
odor When these molecules mix with air, an _____ is produced.

odor 374. When molecules leave a can of paint, they mix with air to produce an _____.

molecules 375. The odor of paint, then, is a kind of gas that contains _____ from the paint.

stimulus 376. Consider an odor that leaves a _____
odor object and comes in contact with a person's nose. How does the _____ stimulate the person's nose?

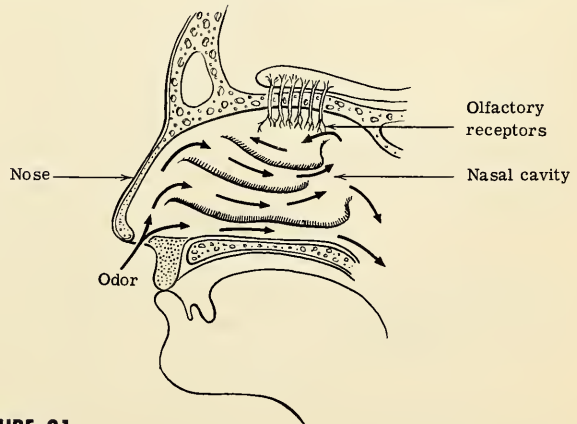


FIGURE 21

odor 377. In Figure 21, we see a diagram of a human nose. The arrows indicate the path of an _____ as it enters the nose.

378. Figure 21 indicates that the odors have entered the nasal cavity. At the top of the nasal _____ you can see the olfactory receptors.

379. The olfactory receptors are at the top of the _____ cavity.

380. There are numerous olfactory receptors at the top of the _____.

381. When we breathe in odors, these odors enter the nasal cavity and come in contact with olfactory _____.

382. We recall that odors contain molecules. When an odor enters the nasal cavity, molecules come in contact with the _____ receptors.

383. When the molecules that are contained in odors enter the _____, they come in contact with olfactory receptors.

384. The molecules in an odor may excite the _____ receptors.

385. If an odor does _____ the olfactory receptors, a nerve impulse is generated.

386. Just as in the case of the receptors in the eye and ear, however, the _____ will not be excited by all odors.

387. That is, the intensity of the odor that comes in contact with olfactory receptors must be above the absolute threshold in order for them to be _____.

388. If the intensity of an odor is above the _____ threshold of the olfactory receptors, then those receptors will set off nerve impulses.

absolute threshold 389. The olfactory receptors will not respond to an odor if its intensity is below the _____.

odor 390. The intensity of an _____ is dependent upon the number of molecules per unit of air.

molecules 391. An odor is rather intense if a certain amount of air contains a lot of _____.

intense/strong 392. But if the air contains relatively few molecules, the odor is not very _____.

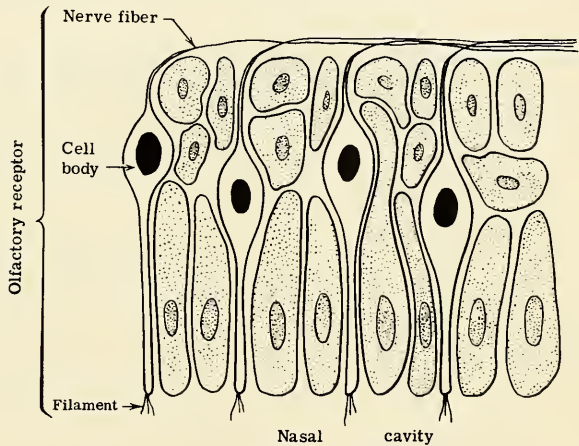


FIGURE 22

olfactory receptors 393. In Figure 22, we see that _____ are tiny cells.

cavity 394. The first part of the olfactory receptor is a fine FILAMENT, or "hair." This filament is the part that projects into the nasal _____.

cell 395. Note that the middle part of the olfactory receptor is the CELL BODY. A _____ body is the part of any cell that nourishes it and "keeps it alive."

nerve 396. The last part of the olfactory receptor is a tiny NERVE FIBER. The _____ fiber is the part that conducts a nerve impulse toward the brain.

397. As you can see, in Figures 21 and 22, the filament (hair) is the part of the _____ that is exposed in the nasal cavity.
398. Thus, the part of the olfactory receptor that comes in contact with the molecules contained in an odor is the _____.
399. When the molecules contained in an odor enter the _____, they strike the filaments of the olfactory receptors.
400. When these molecules strike the _____ of the olfactory receptors, nerve impulses are set off.
401. The activation of the filaments by molecules sets off _____.
402. In this event, the nerve impulse is conducted through the cell body and along the nerve fiber part of the _____.
403. When molecules activate the filaments of olfactory receptors, _____ are conducted through the olfactory receptors.
404. In short, the molecules of an odor activate the part of the olfactory receptor called the _____, which sets off a nerve impulse that runs through the middle part called the _____, and finally along the last part called the _____.
405. We know that the filament end of the olfactory receptor projects into the _____.
406. Because the nerve FIBER is the TOP part of the olfactory receptor, we know that the nerve _____ points in the direction toward the _____ of the head.

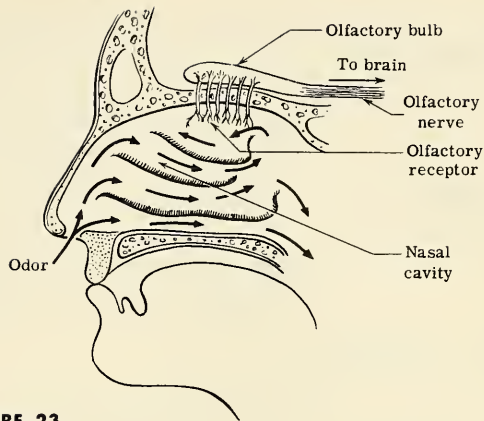


FIGURE 23

407. In Figure 23, we can see that the olfactory receptors connect to the **OLFACTORY BULB**. The nerve fiber end is the part of the olfactory receptor that connects to the _____ bulb.

408. The _____ bulb is made up of a number of tiny nerves.

409. The nerve fibers at the end of the olfactory receptors connect to the tiny nerves in the olfactory _____.

410. We can thus see that when the olfactory receptor is excited, a nerve impulse is conducted to the tiny nerves in the _____.

411. Nerve impulses enter the olfactory bulb from the _____ of the olfactory receptors.

412. Since the olfactory bulb is made up of a number of tiny nerves, nerve impulses may be conducted through it. When molecules strike the _____ of the olfactory receptor, a nerve impulse is generated that runs through the cell body and along the _____ to the tiny nerves of the olfactory bulb.

413. The nerve impulse then runs through the
olfactory bulb _____.

414. Where does the nerve impulse go when it leaves
the olfactory bulb? Study Figure 23 and write your
(read on) answer: _____.

415. As shown in Figure 23, the nerves in the olfac-
tory bulb connect to a major nerve that runs to the
brain _____.

416. The nerve that connects the olfactory bulb to
the brain is called the _____ nerve.
olfactory

417. So we can see that a nerve impulse that leaves
the _____ is transmitted to
the olfactory nerve.
olfactory bulb

418. The nerve that runs from the olfactory bulb to
the brain is called the _____.
olfactory nerve

419. Thus, nerve impulses actually enter the brain
by means of the _____.
olfactory nerve

420. When a nerve impulse is transmitted from the
olfactory receptors to the olfactory bulb, it is further
transmitted to the brain by means of the _____
olfactory nerve

421. Let us now summarize the events that occur in
normal olfaction:

422. Event No. 1: A stimulus object in a per-
son's environment gives off odors that contain
_____.
molecules

423. Event No. 2: When the molecules of the
_____ enter a person's nose, they pass into the
nasal cavity.
odor

nasal cavity 424. Event No. 3: Once the molecules of the odor reach the roof of the _____, they come in contact with the filaments of the olfactory receptors.

filament 425. Event No. 4: When the molecules contained in an odor strike the _____ of an olfactory receptor, a nerve impulse is set off.

nerve impulse
nerve fiber 426. Event No. 5: That _____ is then conducted through the cell body and the _____ of the olfactory receptor.

olfactory bulb 427. Event No. 6: When a nerve impulse leaves the olfactory receptors, it is next transmitted to the _____.

olfactory nerve 428. Event No. 7: The nerve impulse then leaves the olfactory bulb and is transmitted to the brain by means of the _____.

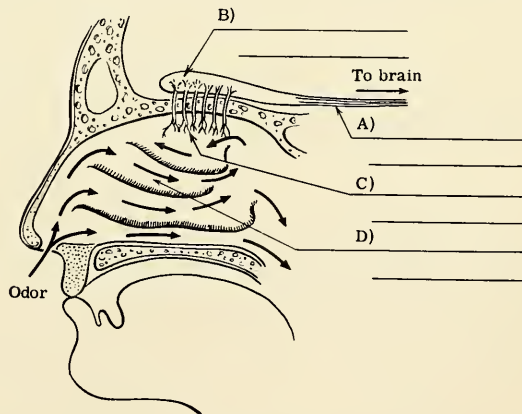


FIGURE 24

429. Label the parts of the nose in the blanks provided in Figure 24.

- A. Olfactory Nerve
- B. Olfactory Bulb
- C. Olfactory Receptors
- D. Nasal Cavity

430. Without looking at the preceding discussion, draw a diagram showing each step from the point at which an odor leaves a stimulus object until the nerve impulse is conducted to the brain.

RECEPTORS

Section V: Gustation

431. The sense of taste may also be called the sense of gustation. GUSTATION is the technical term for *taste* _____.

432. Sometimes we will use the word taste, and sometimes the word *gustation* _____.

433. Hence, a taste stimulus may be referred to as a GUSTATORY stimulus. Rather than say taste stimulus, *gustatory* we will frequently say _____ stimulus.

434. The stimulus object in the case of taste or *gustation* _____ is usually solid or liquid food, such as cake or lemonade.

435. When food, such as a chocolate bar, is placed in the mouth, it dissolves in the water-like substance of the mouth called SALIVA. When food dissolves in the *saliva* _____ of the mouth, the food is "chemically broken down."

436. When food dissolves in _____, the chemicals in the food are "released." The resulting chemicals are the stimuli for *saliva* _____.

gustation/taste

437. Because we place a number of different kinds of foods and liquids in the mouth, there is a variety of chemicals released that can activate the sense of *gustation* _____.

chemicals 438. The chemical breakdown of food in the saliva of the mouth releases chemicals. These _____ serve as **STIMULI** for the sense of gustation.

stimulus 439. When common table salt is placed in the mouth, it dissolves in the saliva. The chemicals that are thus released in solution serve as the _____ for gustation.

gustatory 440. The tongue contains a large number of **TASTE BUDS**. Chemicals that serve as _____ stimuli activate taste buds.

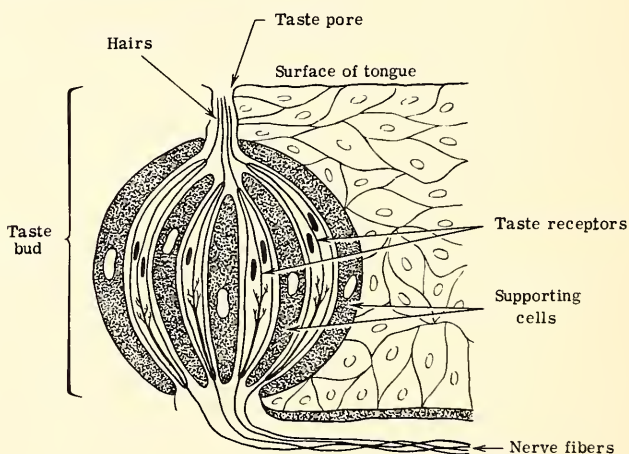


FIGURE 25

Taste 441. In Figure 25, we see a **TASTE BUD**. _____ buds are made up of supporting cells and **TASTE RECEPTORS**.

buds 442. We are not immediately interested in the supporting cells in the taste _____, but shall concentrate more on the **TASTE RECEPTORS** that they contain.

taste bud 443. There are a large number of taste receptors embedded in a single _____.

taste receptors 444. The taste bud contains a large number of _____.

- taste* 445. In Figure 25, we can see that there are several
HAIRS toward the top of the _____ bud.
- taste buds* 446. These small hairs that come out of the _____
_____ project into a small opening that is
called the TASTE PORE.
- taste pore* 447. The opening immediately above a taste bud
is called the _____.
- stimuli* 448. When food goes into solution in the saliva of
the mouth, chemicals are released. These chemicals
are gustatory _____.
- Gustatory* 449. _____ stimuli are chemical in
nature.
- taste pore* 450. The chemicals contained in the saliva enter the
small opening above the taste bud that is called the
_____.
- taste pore* 451. Once the chemicals in the saliva pass through
the _____, they come into contact
with taste receptors.
- saliva* 452. When the chemicals contained in the _____
of the mouth come in contact with taste receptors,
taste they may activate the _____ receptors.
- taste bud* 453. The taste receptors that are embedded within
each _____ may be stimulated by
the chemicals in the saliva (the gustatory stimuli).
- taste receptors* 454. Each taste bud contains a number of taste
receptors. Gustatory stimuli may activate the
_____ that are within
the taste bud.
- gustatory stimuli* 455. Whether or not _____
_____ activate the taste receptors de-
pends on the intensity of those stimuli.

456. If the combined intensity of all the gustatory stimuli in the mouth is above the absolute threshold _____, then they will excite the taste receptors.

457. But if the intensity of the gustatory stimuli is below the _____, then the taste receptors will not be activated.

458. Strictly speaking, gustatory stimuli do not excite the taste bud—they excite the _____ taste receptors _____ within the taste bud.

459. When we say that a taste bud is excited, what we really mean is that the _____ taste receptors contained within the taste bud are excited.

460. We have said that food placed into the mouth, be it solid or liquid, dissolves in the _____ saliva of the mouth.

461. When such food goes into solution, it “chemically breaks down.” The chemicals thus released are embedded in saliva and may serve as _____ gustatory stimuli _____.

462. These gustatory stimuli can then go through the small opening called the _____ taste pore _____.

463. If the intensity of these _____ gustatory absolute threshold stimuli is above the _____, then the taste receptors will be excited.

464. If a gustatory stimulus excites a _____ taste receptor _____, then a nerve impulse is set off.

465. If a gustatory stimulus goes through a taste pore it will come in contact with the taste receptors that are embedded in a _____ taste bud _____.

absolute threshold 466. On the assumption that the gustatory stimulus is sufficiently intense, it is above the _____.

taste receptors 467. In this case, the gustatory stimulus will excite the _____.

taste bud; impulse 468. When the taste receptors in a _____ are excited, a nerve _____ is generated.

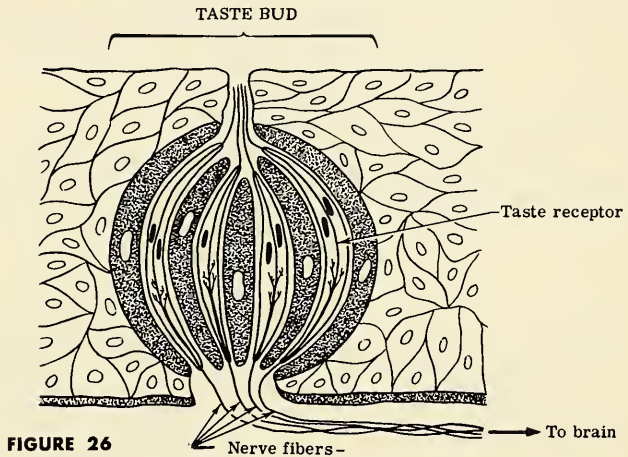


FIGURE 26

nerve fibers 469. The taste receptors connect to NERVE FIBERS that leave the taste bud in which they are embedded. Figure 26 shows the _____ leaving the taste bud.

nerve fibers 470. When the _____ leave the taste buds, they join three major nerves.

nerves 471. These three major nerves are called CRANIAL NERVES. We will not presently be concerned with cranial _____ except to note that they run to the brain.

cranial 472. The cranial nerves will be quite important to us later, at which time we shall consider them in greater detail. For now, we should simply note that the _____ nerves are major nerves that run to the brain.

473. The important point for us to observe here is that tiny _____ run from the taste buds to join three _____ nerves that run to the _____.
- nerve fibers*
cranial
brain
474. We can thus see that when the taste receptors are excited, the nerve impulses they produce leave the taste buds and run to the brain by way of three _____.
- cranial nerves*
475. In the case of audition, vision, and olfaction, nerve impulses run to the _____ by means of a single nerve.
- brain*
476. Why do gustatory stimuli initiate nerve impulses that run to the _____ by means of three different nerves?
- brain*
477. In considering this question, note that taste buds are widely distributed throughout the mouth. Thus, _____ are to be found on the upper surface of the tongue, on the roof and the floor of the mouth, in the cheeks, and on the under side of the tongue.
- taste buds*
478. We do not really know the answer to the question, but we can observe that because taste buds are so widely distributed throughout the mouth, it is difficult for a single nerve to receive nerve impulses from all of them. Considering this wide distribution of taste buds, it seems "more efficient" for three separate nerves to receive _____ from them.
- nerve impulses*
479. Although _____ may be found in various places in the mouth, they appear mainly on the top or UPPER SURFACE of the TONGUE.
- taste buds*
480. More taste buds are found on the upper surface of the _____ than in the cheeks.
- tongue*

upper surface 481. Similarly, more taste buds may be found on the _____ of the tongue than on the roof of the mouth.

tongue 482. We may thus conclude that the upper surface of the _____ is more important for taste than is any other section in the mouth.

taste buds; upper surface 483. The reason for this is that _____ appear predominantly on the _____ of the tongue.

cranial nerves brain 484. The important point for us to note here is that nerve impulses proceed from the taste buds, embedded mainly in the upper surface of the tongue, to three _____ that run to the _____.

✓ *saliva* 485. Let us now summarize the process of gustation. Event No. 1: When a stimulus object, such as food—be it solid or liquid—enters the mouth, it comes into contact with _____ and goes into solution.

stimuli 486. Event No. 2: When the food goes into solution, chemicals that serve as gustatory _____ are released.

taste pores 487. Event No. 3: These stimuli go through the tiny openings called the _____ that lie next to the taste buds.

gustatory taste buds 488. Event No. 4: When these _____ stimuli pass through the taste pores, they come in contact with TASTE RECEPTORS that are embedded in _____.

absolute threshold taste receptors 489. Event No. 5: If these gustatory stimuli are above the _____, they will excite the _____ that are embedded in the taste buds.

nerve impulses

490. Event No. 6: When the taste receptors are excited, they set off _____ that leave the taste buds by means of tiny NERVE FIBERS.

nerve fibers

491. Event No. 7: The nerve impulses are conducted along the tiny _____ to one of three cranial nerves.

*cranial
nerves
brain*

492. Event No. 8: The three _____ then conduct the nerve impulses to the _____.

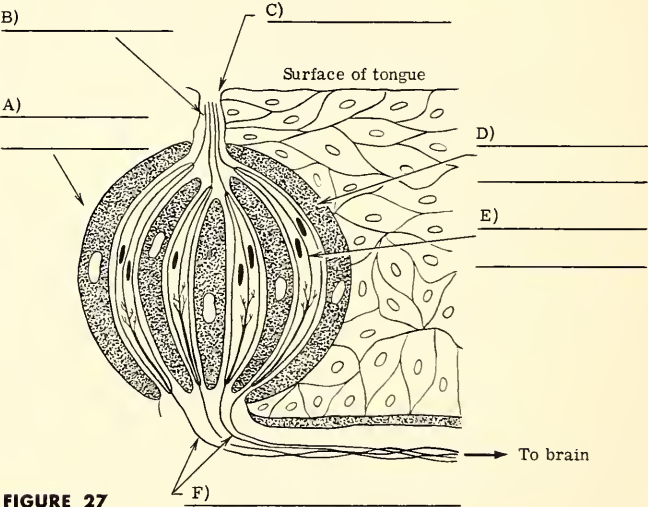


FIGURE 27

- A. Taste Bud
- B. Hairs
- C. Taste Pore
- D. Supporting Cell
- E. Taste Receptor
- F. Nerve Fibers

493. Label the parts in the blanks provided in Figure 27.

494. State each step in the process of gustation, from the point at which food enters the mouth, until a nerve impulse is conducted to the brain. Draw a diagram of a taste bud. Then check yourself against the preceding discussion.

✓ RECEPTORS

Section VI: The Cutaneous Senses

senses 495. We mentioned before that the lay person generally believes that man possesses five senses. These are the _____ of sight, hearing, smell, taste, and touch.

five 496. We have already covered the first four of the above senses, and shall now turn to the sense of touch. As we take up the sense of touch (the skin senses), we will start to see why we say that man has more than _____ senses.

senses 497. The word CUTANEOUS ("kŭ tā'nĭ əs") refers to the skin. We shall now consider the four skin senses, or more properly, the four CUTANEOUS _____.

cutaneous/skin 498. Man has four _____ senses.

cutaneous senses 499. The four _____ that man possesses are those of PRESSURE, PAIN, COLD, and HEAT.

The Cutaneous Senses

Pressure

cutaneous senses 500. We shall consider the _____ in the above order, that is, the pressure sense first, then those of pain, cold, and heat.

501. If you lightly touch a person, you will slightly bend or indent his skin. Such a bending of the *skin* _____ is typically a stimulus for the pressure sense.
502. Bending a person's skin amounts to applying pressure to that person's skin. If the intensity of the *threshold* pressure is above the absolute _____, it is a stimulus.
503. The application of pressure to a person's skin is a pressure stimulus, if its *intensity* _____ is above the absolute threshold.
504. If you indent or bend a person's skin, we can say that you are applying a pressure _____, *stimulus* provided that its intensity is above the *absolute threshold* _____.
505. The part of the skin that we see is only the surface of the skin. Actually, in addition to the surface of the skin, there are several lower layers of *skin* _____.
506. A pressure stimulus, which impinges on a person's skin, will excite receptors embedded in the lower layers of the skin. What are the receptors in the lower *pressure* layers of the skin for receiving _____ stimuli?
507. We have good evidence that pressure *stimuli* _____ can activate three different kinds of receptors.
508. The three types of receptors that respond to *pressure* pressure stimuli are known as _____ receptors.
509. Pressure stimuli may activate three kinds of pressure receptors. The first type of pressure *receptor* _____ that may receive a pressure stimulus is the BASKET NERVE ENDING.

510. One type of receptor that responds to pressure stimuli is the basket _____ ending.

Basket 511. _____ nerve endings are found at the roots of hairs.

basket nerve 512. These _____ endings are simply portions of tiny nerves that wrap around the roots of hairs.

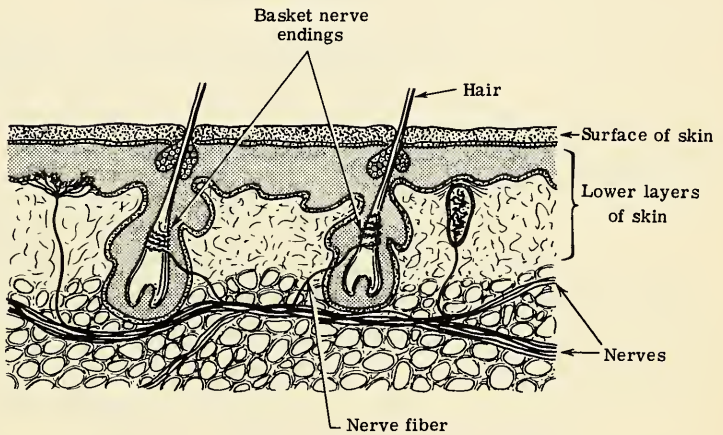


FIGURE 28

basket nerve ending 513. A diagram of the pressure receptor that is called the _____ is shown in Figure 28.

nerve 514. You can see, in Figure 28, that a small nerve fiber runs from the end of the basket nerve ending. This small _____ fiber then goes to a series of larger nerves.

hairs 515. Observe, in Figure 28, how the basket nerve ending wraps around the roots of the hair. Basket nerve endings are always found in close conjunction with the roots of _____.

nerve 516. If the surface of the skin near a hair is bent or depressed, then the basket nerve ending may be activated. If a basket nerve ending is activated a _____ impulse results.

- basket nerve ending* 517. The depression of the skin near a hair may activate a _____ to set off a nerve impulse.
- activated/excited
nerve impulse* 518. When a basket nerve ending is _____, a _____ results.
- basket nerve ending* 519. Will any depression of the skin near a hair activate a _____ to set off a nerve impulse?
- intensity* 520. The answer is No. The reason for this answer is that the pressure stimulus must be of sufficient _____ (sufficiently "strong") to activate the basket nerve ending.
- pressure
absolute threshold* 521. If the bending or depression of the skin produces a _____ stimulus that is above the _____, then the basket nerve ending will be excited.
- absolute
threshold; impulse* 522. The activation of a basket nerve ending by a pressure stimulus above the _____ produces a nerve _____.
- roots* 523. You will recall that the basket nerve ending wraps around the _____ of a hair. As you would expect, then, if only the hair itself is moved sufficiently, the basket nerve ending will be _____.
- activated/excited* 524. In other words, a basket nerve ending may be excited by touching the skin or by moving a _____.
- hair* 525. In either case, if the _____ is activated, a nerve impulse is produced.
- basket nerve
ending* 526. Once the basket nerve ending produces a _____, that nerve impulse is conducted along the tiny _____ fiber that is shown in Figure 28.
- nerve impulse
nerve*

527. The nerve impulse is then transmitted along the tiny _____ to larger nerves.

528. The PRESSURE RECEPTORS are widely distributed throughout the skin of the body. Because of this wide distribution, the nerve fibers of these _____ connect to more than just one nerve which conducts nerve impulses to the brain.

529. There is a large and complex network of nerves that conduct _____ from the pressure receptors to the _____.

530. We have said that there are THREE kinds of pressure receptors. The first kind of pressure receptor that we discussed is the _____.

531. The basket nerve ending is the pressure receptor for parts of the skin that contain hairs. Let us now consider the other _____ kinds of pressure receptors.

532. The second kind of _____ that we shall consider is the MEISSNER (Miz'ner) CORPUSCLE.

533. The Meissner _____ is embedded in the skin in the hairless regions of the body.

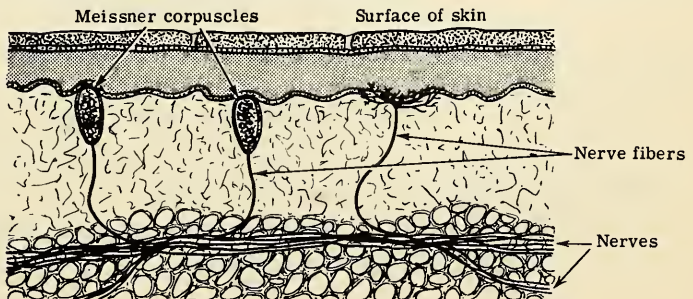


FIGURE 29

534. In Figure 29, you can observe a _____ corpuscle.

*Meissner
corpuscle*

535. If the skin is bent or depressed in a region of the body that lacks hairs, it will probably activate the pressure receptor called the _____.

*nerve
fiber*

536. We saw that a tiny nerve fiber is attached to the basket nerve ending. In like manner, a tiny _____ is attached to the end of a Meissner corpuscle.

brain

537. This tiny nerve then joins larger nerves. The network of larger nerves eventually runs to the _____.

nerve impulse

brain

538. Hence, if a Meissner corpuscle is activated, the resulting _____ is transmitted along the tiny nerve fiber to the larger nerves and then to the _____.

*Meissner
corpuscle*

539. The basket nerve ending and the _____ are both activated by pressure stimuli.

*nerve impulses
nerve fibers*

brain

540. In the case of both of these pressure receptors, the resulting _____ are then transmitted along tiny _____ to a series of major nerves and then eventually to the _____.

*hairs
Meissner corpuscle
pressure*

541. The basket nerve ending picks up pressure stimuli in regions of the skin that contain _____, whereas the _____ picks up _____ stimuli in the hairless regions of the skin.

*pressure
receptor*

542. The third type of _____ is the FREE NERVE ENDING.

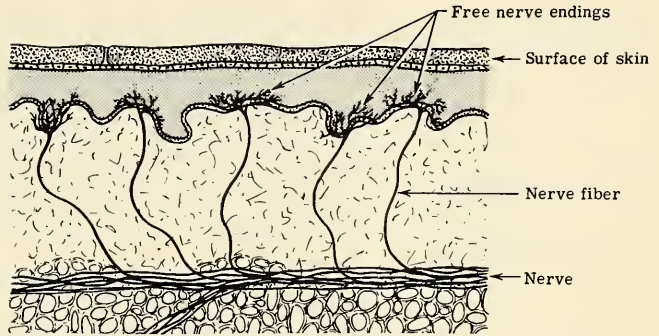


FIGURE 30

543. As you can see in Figure 30, a free nerve _____ consists of a large number of tiny nerve branches.

544. Like the basket nerve ending and the Meissner corpuscle, the _____ is activated when the skin is bent or depressed.

545. Also, like the other two types of pressure receptors, a tiny _____ runs from the end (is actually part) of the free nerve ending.

546. When a _____ is activated, a _____ results.

547. This nerve impulse is conducted along the tiny _____ that runs to a series of larger nerves.

548. By continuing along the larger nerves, the nerve impulse finally enters the _____.

549. Let us now summarize the process by which a pressure stimulus produces a _____ that is transmitted to the _____.

550. Event No. 1: When a person's skin is touched, the skin is slightly depressed or _____.

pressure stimulus

551. Event No. 2: The bending of the skin may be a _____.

*intensity
absolute
threshold*

552. Event No. 3: When a pressure stimulus is applied to the surface of the skin, a pressure receptor is activated, providing the _____ of the pressure stimulus is above the _____.

*basket nerve ending
Meissner corpuscle
free nerve ending
(different order is
all right)*

553. Event No. 4: There are three types of pressure receptors that can be activated. These are the:

_____,
_____, and
_____.

*pressure
receptor*

554. Event No. 5: The activation of a _____ produces a nerve impulse.

*nerve impulse
nerve fiber
brain*

555. Event No. 6: When a nerve impulse is set off by a pressure receptor, that _____ is conducted along a tiny _____ to a series of larger nerves and thence to the _____.

556. Without looking at the preceding discussion, draw a diagram of each of the three types of pressure receptors, label them, and state the steps from the point at which a pressure stimulus activates them, to the point at which a nerve impulse is conducted toward the brain.

The Cutaneous Senses

Pain

cutaneous

557. We have now considered the first CUTANEOUS sense, that of pressure. Let us turn to the second _____ sense, that of PAIN.

pain 558. In discussing the other senses, we were able to specify a single stimulus, but this is not possible for the sense of _____.

pain 559. The reason for this is that many different stimuli can produce _____.

stimuli 560. Consider the wide variety of _____ that can produce pain. Some examples of PAIN STIMULI are pinching the skin, being hit by a hard object, excessive heat, cuts, and pricks.

Pain 561. The wide variety of stimuli that can produce pain make one point clear: they all can damage the body tissues. _____ stimuli thus help us to survive.

stimuli 562. That is, pain _____ warn us of potential damage to our bodies.

pain 563. There are some people who cannot feel _____. These people are often the victims of serious injury.

stimuli 564. For instance, if a person does not have PAIN RECEPTORS, then he cannot receive pain _____. In this event, he can be seriously burned, cut, or otherwise injured without reacting.

pain receptors 565. In other words, the activation of _____ by pain stimuli usually warn us that our body is being damaged.

pain 566. Whenever we feel _____, we immediately react in order to reduce or remove the pain.

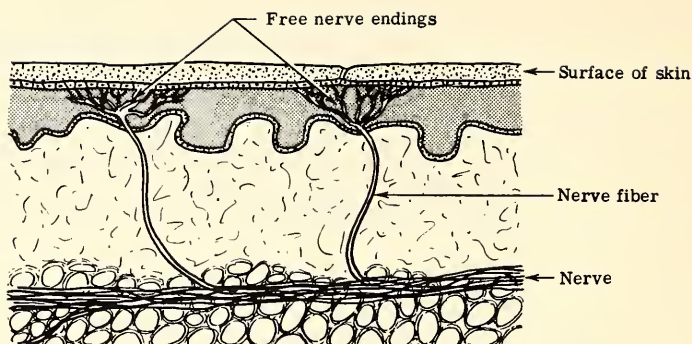


FIGURE 31

567. In Figure 31, you see a diagram of a free nerve
ending _____.

nerve 568. Free _____ endings are embedded in the
 SKIN and widely distributed throughout the body.

pain 569. Thus, we do not only feel pain in the skin; we
 can also feel _____ in the deeper, or internal
 parts of the body.

free 570. We feel pain in the internal portions of our
 body when _____ nerve endings in those parts
 are activated.

receptor 571. A pain stimulus can activate a free nerve ending
 regardless of whether that pain _____
 is located in the skin or in the internal parts of the
 body.

free nerve endings 572. Some organs of the body do not contain
 _____.

free nerve 573. For this reason, we cannot feel pain in certain
endings portions of the body. The lungs are an example of an
 organ that does not contain _____.

pain stimulus 574. For this reason a _____
 applied directly to the lungs fails to produce pain.

nerve impulse 575. If a pain stimulus activates a free nerve ending, then a _____ is set off.

stimulus 576. The pain _____ may be any of a variety such as those that we previously mentioned. For example, acid, thrown on the skin, would probably activate _____ to set off _____.

*free nerve endings
nerve impulses*

*free
nerve endings* 577. Pain stimuli seem to activate _____ by causing them to STRETCH.

stretch 578. When a pain stimulus activates a free nerve ending, it apparently does so by causing it to _____ in a lengthwise ("up and down") direction.

free nerve endings 579. When a pain stimulus is applied to the body, there is apparently a lengthwise stretching of _____.

*nerve fiber
nerves* 580. As you can see in Figure 31, the free nerve ending is continuous with a tiny nerve fiber. The tiny _____ is actually part of the free nerve ending that runs to large _____.

*activated/stretched
pain stimulus* 581. Hence, when a free nerve ending is _____ by a _____, the resulting nerve impulse is conducted along the tiny nerve fiber to large nerves.

brain 582. The nerve impulse is then conducted, by means of a complex set of these large nerves, to the _____.

pain stimuli 583. Let us now summarize what we have said about the sense of pain. Event No. 1: A wide variety of stimuli may produce the feeling of pain. These stimuli are called _____.

free nerve endings

584. Event No. 2: When pain stimuli are applied to the surface or to the internal portions of the body, they may activate pain receptors which we call _____.

stretch

585. Event No. 3: These pain stimuli activate free nerve endings by causing them to _____ in a lengthwise fashion.

nerve impulse

586. Event No. 4: When a free nerve ending is activated, it sets off a _____.

*nerve fiber
brain*

587. Event No. 5: When a free nerve ending sets off a nerve impulse, that nerve impulse is conducted along a tiny _____ to a series of large nerves and finally to the _____.

588. Without looking at the preceding discussion, draw a diagram of a free nerve ending connecting to the larger nerves that run to the brain. State each step that occurs from the point at which a pain stimulus impinges on the organism to where a nerve impulse is conducted toward the brain. Then check yourself against the preceding discussion.

The Cutaneous Senses

Temperature

cutaneous

589. Because they are embedded in the skin, the TEMPERATURE SENSES are classified along with pressure and pain as _____ senses.

temperature

590. We are not sure, but there is good reason to believe that there are two different receptors for _____ embedded in the skin.

*temperature
receptor*

591. It is likely that one of these is a temperature receptor for heat and one, a _____ for cold.

cold 592. The problem of identifying the receptors for heat and for _____ is an extremely difficult one, and has not yet been solved with a great degree of certainty.

heat 593. There is good reason to believe, however, that the receptors for cold lie near the surface of the skin, whereas the receptors for _____ are embedded in the lower layers of the _____.
skin

heat 594. The receptors for _____ are more deeply embedded in the skin than are the receptors for _____.
cold

receptors 595. We do know that these two different types of temperature _____ are widely distributed throughout the body.

heat 596. That is, we can experience _____ and _____ at widely different places in the body.
cold
(either order)

temperature 597. The temperature of the skin varies between different portions of the body. For example, the temperature in the ear is normally about 82° F., whereas the _____ in the armpit is about 98° F.

temperature 598. The normal _____ of the face and hands is about 90° F.

temperature 599. But the temperature in any given cutaneous (skin) region is usually quite CONSTANT. For example, the _____ of skin of the face is almost always about 90° F.

body 600. We can thus see that the temperature is different for various parts of the _____.

constant 601. But in any given cutaneous region, the temperature is usually quite _____.

environment 602. We know that the stimuli that come from the stimulus objects in our _____ exist at different temperatures. To take an extreme example, the temperature of ice is much lower than that of this book.

cutaneous 603. The word cutaneous refers to the skin. Hence, a region of the skin may be referred to as a _____ region.

colder/cooler 604. If a stimulus object, such as a piece of ice, is placed on one cutaneous region of the face, that region becomes _____ than other cutaneous regions of the face.

cutaneous 605. The piece of ice would, then, lower the temperature of that particular _____ region of the face below its normal 90° F.

*cutaneous
nerve
impulses* 606. If a piece of ice is placed on a particular cutaneous region of the face, the cold receptors which lie in the upper surface of that _____ region would be activated to set off _____.

cutaneous 607. Any stimulus object that will reduce the temperature of a _____ region by about 2° F. will cause one to feel cold.

nerve impulses 608. That is, if a stimulus object changes the temperature of a particular cutaneous region by about 2° F., the cold receptors in that region will be activated to set off _____.

*cutaneous
heat* 609. In like manner, any stimulus object applied to a _____ region that is approximately 2° F. HOTTER than that region will activate receptors for _____.

610. Stimulus objects that increase the temperature of a cutaneous region activate heat receptors, while stimulus objects that reduce or decrease the temperature of a cutaneous region activate _____ receptors.

cold

611. That is, if a stimulus object INCREASES the temperature of a cutaneous region by about 2° F., a _____ will be activated.

heat receptor

612. If a stimulus object REDUCES the temperature of a cutaneous region by about 2° F., a _____ will be activated.

*cold
receptor*

613. When either a cold or a hot stimulus object activates a temperature receptor, a _____ is set off.

*nerve
impulse*

614. This nerve impulse is then conducted by a series of nerves to the _____.

brain

615. To summarize—Event No. 1: Stimulus objects in our _____ exist at different temperatures.

environment

616. Event No. 2: The surface of the skin in any given region of the body is normally at a constant _____.

temperature

617. Event No. 3: If a HOT stimulus object is applied to a particular cutaneous region, the temperature of that _____ region is _____.

*cutaneous
increased/raised*

618. Event No. 4: If a hot stimulus object increases the temperature of a cutaneous region by about 2° F., then a _____ receptor is activated. The stimulus, in this event, is above the _____ of the heat receptor.

*heat
absolute
threshold*

619. Event No. 5: If a heat receptor is activated, a _____ is set off.

nerve impulse

cold receptor

620. Event No. 6: If a stimulus object is at least 2° F. below the temperature of a cutaneous region, then a _____ is activated to set off a nerve impulse.

*cold receptor
nerve impulse
brain*

621. Event No. 7: The activation of either a heat receptor or a _____ sets off a _____ that is conducted to the _____ by means of a series of large nerves.

622. State each step from the point at which a cold or hot stimulus object is applied to the body, to the point where a nerve impulse is conducted toward the brain, then check yourself against the preceding discussion.

✓ GENERAL SUMMARY OF THE CUTANEOUS SENSES:

*pain
temperature*

623. We can thus see that there are four cutaneous senses. One for pressure, one for _____, and two for _____.

*four
skin*

624. The _____ cutaneous senses may be activated when stimulus objects impinge on a person's _____.

pressure stimulus

625. The stimulus that indents or bends the skin is called a _____.

*absolute
threshold*

626. If a pressure stimulus is above the _____, it may activate one of three types of pressure receptors.

*three
basket nerve endings
Meissner corpuscles
free nerve endings
(different order is
all right)*

627. The _____ types of pressure receptors are: _____, _____, and _____.

- pressure* 628. The type of _____ receptor found
hairs next to the roots of _____ is called the
basket nerve ending _____.
- Meissner* 629. The name of the pressure receptor found in
corpuscle hairless regions of the body is the _____.
- pressure* 630. When a pressure receptor is activated, excited,
nerve or stimulated by a _____ stimulus
impulse from a person's environment, a _____
 _____ is generated.
- nerve fiber* 631. The nerve impulse is then conducted along a
brain tiny _____ to a series of larger
 nerves and finally to the _____.
- cutaneous* 632. The second _____ sense that we
 considered was that for pain.
- environment* 633. A wide variety of stimuli from a person's
 _____ may activate the sense of
 pain.
- stimulus* 634. If a pain _____ impinges on an
free nerve ending organism, it will excite the pain receptor called a
 _____.
- excites/activates* 635. When a pain stimulus _____ a free
nerve impulse nerve ending, a _____ is gen-
 erated.
- nerves* 636. The nerve impulse is then conducted along a
brain tiny nerve fiber to a series of large _____,
 which ultimately deliver the nerve impulse to the
 _____.
- impinges* 637. The same general process occurs in the case of
 the temperature sense. That is, a stimulus from a per-
 son's environment _____ on an organ-
 ism.

638. If the stimulus is at least 2° F. hotter than the _____ region with which it comes in contact, then _____ receptors will be excited.

639. But if the stimulus is at least 2° F. colder than the cutaneous region, it will activate _____.

640. In either case, a _____ nerve impulse is generated that is conducted along a tiny _____ fiber; nerves _____ to a series of large _____ that conduct the impulse to the _____ brain.

RECEPTORS

Section VII: The Kinesthetic Sense

641. The KINESTHETIC (kĭn əs thět'ĭk) SENSE is one of which most people are not aware. This may be because the receptors for the kinesthetic _____ are strictly internal and cannot normally be seen.

642. Additionally, the kinesthetic sense works almost in an "automatic" fashion. That is, the _____ sense functions regardless of whether or not we "pay attention" to it.

643. But the kinesthetic sense is of extremely great importance to us. For one thing, the _____ "tells" us about the location of our LIMBS in space.

644. Suppose that you close your eyes and place your left arm behind you. You "know" perfectly well where your left arm is in space. This knowledge is due to the functioning of the _____ in that arm.

645. The sense of KINESTHESIS (kin'es-the'sis) provides information about the location of our _____ in space.

646. Actually, however, a more important function of the sense of _____ is to help COORDINATE and INTEGRATE behavior.

- kinesthesia* 647. The sense of _____ is essential for all types of smooth, *integrated* (coordinated) behavior such as walking, driving a car, writing a letter, and pitching a baseball.
- integrated* 648. Behavior that is not well coordinated or *INTEGRATED* would be erratic and "jerky." A person who did not walk in a smooth fashion would make jerky movements. Such behavior could not be called coordinated or _____.
- kinesthetic* 649. If you did not receive information by means of your _____ sense, you would find that such activities as walking would be extremely difficult, if not impossible.
- integrated* 650. This point is well illustrated in some clinical cases involving syphilis. Individuals in advanced stages, for instance, manifest jerky and erratic movements. Such lack of coordinated or _____ behavior is due to improper functioning of the kinesthetic sense.
- kinesthetic* 651. In such cases, the only way he can tell where his limbs are is to see them. Hence, such a person walks in a very jerky and uncoordinated fashion. Such lack of integration is due to improper functioning of the _____ sense.
- location/position* 652. We can thus see that there are two functions of the kinesthetic sense. One function is to provide information about the _____ in space of a person's limb.
- function integrate* 653. The second _____ is to help coordinate and _____ such activities as walking.
- receptors* 654. Like the other senses, there are *RECEPTORS* for the kinesthetic sense. These receptors are called kinesthetic _____.

receptors 655. Kinesthetic _____ are found in three different places in the body. These are (1) in the muscles, (2) in the tendons, and (3) in the linings of the joints.

kinesthetic 656. Let us first consider the _____ receptors in the MUSCLES.

muscles 657. The kinesthetic receptors in the _____ are called MUSCLE SPINDLES.

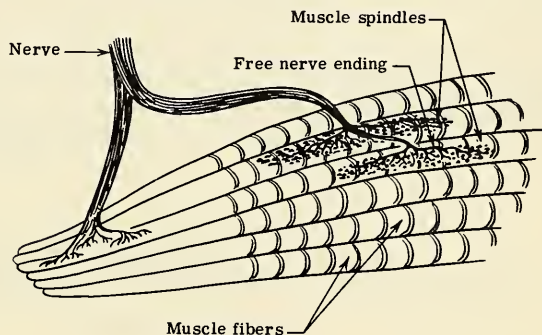


FIGURE 32

muscle 658. In Figure 32, you see a diagram of a portion of a muscle with a _____ spindle.

spindle 659. The muscle _____ is surrounded by free nerve endings.

spindle 660. When a muscle is stretched or contracted the muscle _____ is activated.

muscle spindle 661. When a _____ is activated, a nerve impulse is set off.

nerve impulse 662. The _____ is then transmitted along to the free nerve endings, and then by way of a series of nerves to the brain.

muscle spindle 663. The kinesthetic receptor that is activated when a muscle stretches or CONTRACTS is a _____.

664. When a person moves his arm, he naturally contracts _____ the various muscles in it. The contraction and stretching of those _____ provides the stimulus that _____ the kinesthetic receptors (in the muscles) called the _____.
665. The activation of the _____ in this manner generates _____ that are transmitted to free nerve endings.
666. Once a nerve impulse is received by the _____, it is then conducted along to larger nerves and finally reaches the _____.
667. By thus activating the muscle spindles we receive information about the _____ of our limbs in space.
668. Because we are almost constantly moving the limbs of our body, we are constantly contracting and stretching a large number of muscles. We can thus see that an enormous number of _____ in our muscles are being activated and consequently a very large number of _____ are being transmitted to the _____ from these kinesthetic receptors.
669. We have just considered the first type of kinesthetic receptor. The second type of _____ to consider is that embedded in the tendons.
670. TENDONS are groups of fibers that do not stretch to any appreciable extent. MUSCLES are connected to BONES by means of these groups of fibers called _____.

671. You may think of tendons as being like small but very strong pieces of rope. Tendons connect the *bones* muscles to _____.

muscles 672. Tendons are connected to _____ at
bones one end and to _____ at the other end.
(either order)

tendon 673. If a muscle group (such as one in the upper arm) contracts, the forearm (the part of the arm below the elbow) can move up. The reason that the forearm moves up is that the muscles of the upper arm pull on the _____ that is attached to the bone of the forearm.

tendons 674. When the muscles pull on _____, the bones attached to those tendons move.

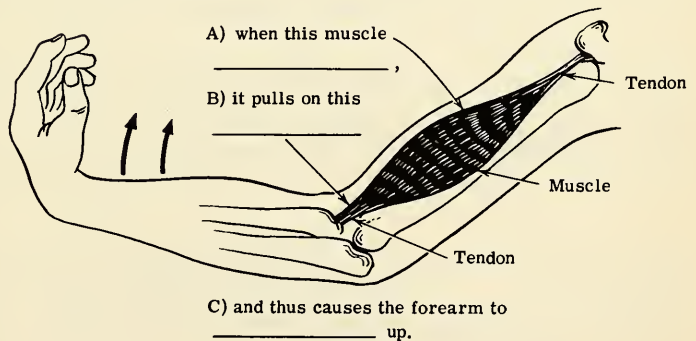
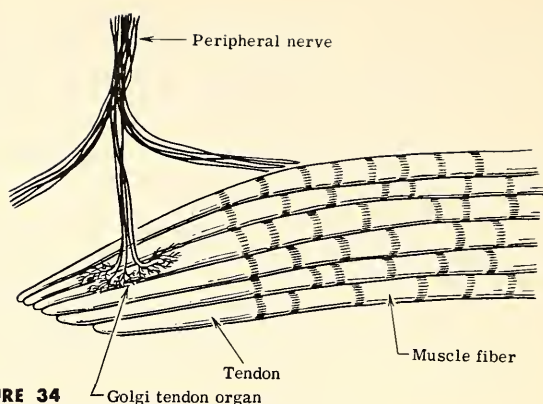


FIGURE 33

675. In Figure 33, you can see a diagram of this process. Fill in the blanks provided.

A. Contracts
B. Tendon
C. Move, pull, draw, etc.

tendons 676. The type of kinesthetic receptor contained in _____ is called the GOLGI TENDON ORGAN.


FIGURE 34

677. In Figure 34, we see a diagram of a Golgi tendon _____ organ.

678. As you can see, the tiny nerve fiber of the Golgi tendon organ _____ connects with larger nerves.

679. Hence, when a _____ organ is activated, _____ are generated and conducted along the tiny nerve fibers to these larger nerves that carry them to the _____.

680. When a muscle contracts, it pulls on, or places tension on, the attached tendons. When tension is thus placed on a tendon, the _____ in those tendons may be activated.

681. Whether or not the Golgi tendon organs are actually excited depends upon whether or not the tension placed on the tendons is above the absolute _____.

682. When we move our legs, the muscles in those legs contract. The contraction of those muscles places tension on the attached _____.

683. When such tension is placed on the tendons, the _____, embedded in those tendons, are activated to set off _____.

- kinesthetic* 684. The Golgi tendon organ is the second kind of _____ receptor that furnishes us with information about the location of various parts of our body.
- Golgi tendon organs* 685. The activation of _____ in the tendons also helps us to manifest smooth, integrated, coordinated behavior.
- muscle spindle tendons* 686. The kinesthetic receptor contained in muscles is the _____, whereas the kinesthetic receptor contained in _____ is the Golgi tendon organ.
- Golgi tendon organs*
nerve impulses 687. Typically when a muscle contracts, the associated muscle spindles and the _____, in the attached tendons, are activated to set off _____.
- kinesthetic receptor* 688. The third type of _____ to consider is that found in the LININGS of the JOINTS.
- joint* 689. Between the forearm and the upper arm is a JOINT at the point commonly called the elbow. This _____ contains a number of kinesthetic receptors.
- joints* 690. Essentially, there is a joint at every point in the body where two bones come together. For example, we have _____ at the knee, at the ankle, and in the shoulder.
- kinesthetic receptors* 691. We are not really sure what kind of _____ are found in the joints.
- joint* 692. We do know, however, that whenever a limb moves, the kinesthetic receptors in the linings of the _____ are stimulated.

*kinesthetic
receptors*

693. The stimulation of the _____
_____ in the linings of the joints tells
us something about the relative location of the two
bones that meet in the joint.

*joints
bones*

694. That is, the activation of the kinesthetic re-
ceptors in the linings of the _____ informs us
that the two _____ that meet in the joint are in
a certain location.

lining

695. For example, when we change the location of
our upper and lower arms, the kinesthetic receptors
in the _____ of the joint, called the elbow, are
stimulated.

*nerve impulses
brain*

✓ 696. When these kinesthetic receptors are activated,
they generate _____ that are
conducted to the _____ by a series of nerves.

*muscle spindles
Golgi tendon
organs
linings*

697. We have discussed three types of kinesthetic
receptors. These are the _____
that lie in the muscles, the _____
_____ that are contained in the tendons, and cer-
tain unknown kinesthetic receptors that lie in the
_____ of the joints.

free nerve endings

698. We have noticed that free nerve endings are
widely distributed throughout the body and we have
observed that these _____
can serve a variety of functions.

free nerve endings

699. Although it is not at all certain, it is entirely
possible that _____
sometimes also serve as kinesthetic receptors.

*kinesthetic
receptor*

700. Hence, it may well be that free nerve endings
are a fourth type of _____. Let us see why this is so.

701. First let us note that all muscles contain a number of small blood vessels. Blood flows along these muscles blood vessels contained in the _____.

702. Next, we know that free nerve endings are also contained in muscles. These _____ connect to the blood vessels contained within the _____.

703. Muscles contain free nerve endings that connect to the numerous _____ that conduct blood.

704. Every blood vessel in the body contains very tiny muscles. Therefore, the blood vessels, embedded in a large muscle themselves, contain tiny _____.

705. When the tiny muscles in the _____ vessels that are contained in muscle groups contract, it seems likely that they activate the _____ that are attached to them.

706. When the tiny muscles of the blood vessels contract, they may activate free nerve endings to set off _____.

707. In some manner, it seems that these free nerve endings are excited by the _____ of the tiny muscles in those blood vessels.

708. Hence, to be complete, we should note that _____ may also furnish us information about the location of our limbs.

709. Let us now summarize the functioning of the _____ kinesthetic sense.

- ✓ 710. When a portion of the body is in motion, _____ are
kinesthetic receptors _____
 activated.
711. We know that there are at least three types of
*activated/excited/
 stimulated* kinesthetic receptors that may be _____
 when the body moves.
712. These three types of kinesthetic receptors are
muscle spindles the _____ of the muscles, the
Golgi tendon organs _____ of the ten-
 dons, and certain unknown receptors in the linings
joints of the _____.
713. In addition, we suspect that there is a fourth
 type of kinesthetic receptor. We know that muscles
 contain blood vessels, and that blood vessels them-
 selves contain tiny muscles. This fourth type of kine-
 sthetic receptor is activated when the tiny muscles con-
contract tained in blood vessels _____.
714. This fourth possible type of kinesthetic receptor
free nerve ending is called the _____.
715. When a muscle stretches, the kinesthetic re-
muscle ceptor in the muscle, called the _____
spindle; nerve _____, is activated to set off a _____
impulse; brain _____ that is transmitted to the _____.
716. When a muscle contracts, tension is placed on
tendon the attached _____. In this event, the kine-
 sthetic receptors, embedded in the tendons, called the
Golgi tendon organs _____, are acti-
nerve impulses vated to send off _____.
717. When the bones that meet in the joints are
linings moved, the kinesthetic receptors in the _____
joints of those _____ are activated to set off
nerve impulses _____ that are eventu-
brain ally conducted to the _____.

location/position

integrated

718. All of these kinesthetic receptors serve to furnish information about the _____ of the various portions of our body and help us to develop smooth, coordinated, _____ behavior.

719. Without looking at the preceding discussion, state each step from the point at which a stimulus impinges on, and thus activates, a kinesthetic receptor, to the point at which a nerve impulse is conducted to the brain. Consider each of the four receptors that we discussed separately, then go back and check yourself against the preceding discussion.

RECEPTORS

Section VIII: The Vestibular Sense

location/position 720. We have just seen that the sense of kinesthesia “tells” us about the movement and the _____ of our limbs in space.

sense 721. Information about movement and position is also furnished by the VESTIBULAR (“vēs tīb’yə lər”) SENSE. More specifically, the position of our body in space is furnished us by the vestibular _____.

vestibular 722. The kinesthetic sense informs us of the position of our limbs in space, while the vestibular sense informs us of the general orientation, location or position of our entire body in space. For example, we know that we are right side up instead of upside down due to the functioning of the _____ sense.

kinesthetic 723. If one of your limbs, such as your arm, is placed behind your back, information about its location is furnished by the _____ sense.

vestibular 724. But the information that you are standing right side up, rather than standing on your head, is furnished by the _____ sense.

vestibular sense 725. If a person closes his eyes, he still has a good idea about the location of his body in space. This information is furnished by the _____.

kinesthetic 726. The location of one of your limbs, such as your
vestibular leg, is furnished by the _____
sense, rather than by the _____
sense.

inner ear 727. You will recall that the organ for hearing, the
cochlea, is located in the inner ear. Other structures
are also located in the _____.

cochlea 728. The _____ is the organ for hearing,
inner and it is located in the _____ ear.

vestibular 729. The other structures in the inner ear have nothing
to do with hearing, but rather concern the _____
sense.

inner ear 730. There are two general types of organs in the
_____ besides the cochlea.

vestibular 731. These are first, the SEMI-CIRCULAR CANALS, second,
the UTRICLE and SACCULE. Both the semi-circular
canals and the utricle and saccule have to do with the _____
sense.

cochlea 732. The part of the inner ear that has to do with
the sense of hearing is the _____.

inner 733. The SEMI-CIRCULAR CANALS and the utricle and
saccule are also located in the _____ ear.

vestibular sense 734. The semi-circular canals and the utricle and
saccule, however, have nothing to do with hearing,
but they function in connection with the _____.

canals 735. In studying the vestibular sense, let us first
consider the semi-circular _____.

semi-circular 736. There are three _____
canals.

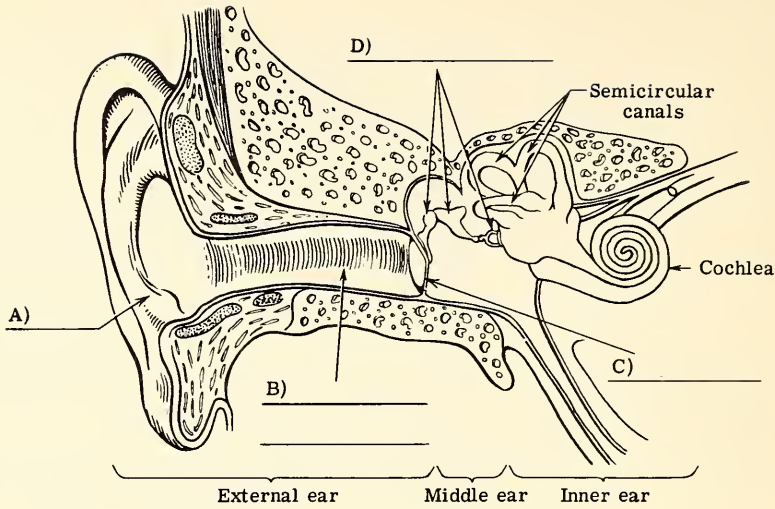


FIGURE 35

737. In Figure 35, you see a diagram of the external ear, the middle ear, and the inner ear. Fill in the blanks.

- A. Pinna
- B. Auditory canal
- C. Eardrum
- D. Ossicles

738. Note that the semi-circular canals are located in the _____ directly above the _____.

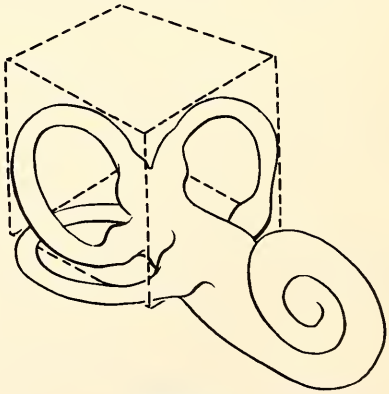


FIGURE 36

739. In Figure 36, you see a larger diagram of the _____
semi-circular canals

740. Now look at the bottom corner of a room. You see that there are THREE PLANES; each plane is perpendicular to the other. That is, the floor is in the horizontal plane, while the two walls, which meet at the corner, are in the vertical planes. The three semi-circular canals roughly correspond to the three _____ that meet in the corner of a room.

planes

741. As can be seen in Figure 36, there is a semi-circular canal for the horizontal plane and two _____ for the two vertical planes.

semi-circular canals

742. The three _____ are thus approximately perpendicular to each other.

semi-circular canals

743. As we shall soon see, the semi-circular canal for each plane furnishes us with information about our movement in each of the three _____.

planes

744. Each _____ is filled with a FLUID.

semi-circular canal

fluid

745. Immersed in the _____ of each semi-circular canal is a set of HAIR CELLS very much like the hair cells in the cochlea.

hair

746. Each semi-circular canal contains a set of _____ cells that is immersed in a fluid.

hair cells

fluid

747. The _____ inside of each semi-circular canal are immersed in _____.

nerve fibers

brain

748. Just as in the cochlea, the hair cells of the semi-circular canals terminate in small nerve fibers. These small _____ connect with the auditory nerve that leads to the _____.

*semi-circular
canals*

749. When the head is rotated, pressure builds up in the fluid inside the _____.

fluid 750. Rotation of the head increases the pressure of the _____ contained in the semi-circular canals.

hair cells 751. Because the hair cells inside the semi-circular canals are immersed in fluid, such an increase in pressure of the fluid can affect these _____.

hair cells 752. An increase in the pressure of the fluid of the semi-circular canals can activate the _____.

pressure 753. The hair cells contained in the semi-circular canals are activated when there is an increase in the _____ of the fluid.

nerve impulses 754. Recall that small nerve fibers leave the ends of the hair cells. The activation of the hair cells generates _____ that run along the small nerve fibers.

nerve 755. The nerve impulses are then conducted to the brain by means of the major nerve called the auditory _____.

auditory 756. Nerve impulses are conducted from the semi-circular canals along the large nerve called the _____ nerve and then to the brain.

fluid 757. Movement of the head, such as occurs in rotation, causes an increase in the pressure of the _____ inside the semi-circular canals.

pressure 758. Such an increase in the _____ of the fluid produces an increase in pressure on the hair cells.

hair cells 759. This increased pressure on the _____ activates them.

760. When the hair cells are activated in this manner, they generate _____ that are conducted along tiny nerve fibers.

761. The impulse then leaves the tiny nerve fibers and runs along the major nerve, called the _____, to the brain.

762. Actually, however, it is not the movement or the rotation of the head itself that produces the stimulus for the _____ sense.

763. To understand this, observe that when the head is rotated it increases and decreases speed. It is the decreasing or increasing of speed that produces the _____ for the vestibular sense.

764. Any time one moves his head in any direction he necessarily increases and _____ the speed of its movement.

765. When one increases or decreases the speed with which he moves his head, he changes the pressure of the _____ within the semi-circular canals.

766. Such changes in the pressure of the fluid within the semi-circular canals, then, can activate the _____ to set off nerve impulses.

767. Nerve impulses generated by the hair cells are then conducted along the tiny nerve fibers to the _____ nerve, and finally to the _____.

768. Suppose that you are standing still and start to walk. In this event, the _____ sense will be _____.

769. But if the head is moving at a constant speed in a constant direction, you are neither increasing nor decreasing your speed. In this event, the vestibular sense will _____ be activated.

vestibular
semi-circular canals
hair cells

770. In short, any time a person's head increases or decreases speed in any direction (forward, backward, sideways, or in a circular fashion), the _____ sense will be activated—pressure will be produced in the fluid within the _____, which in turn activates the _____ to generate nerve impulses.

vestibular

771. The direction in which we are moving is thus known to us by means of the semi-circular canals of the _____ sense.

inner

772. Let us now turn to the second set of organs in the _____ ear having to do with the vestibular sense—the UTRICLE (ū'trə kəl) and SACCULE (sāk'ül).

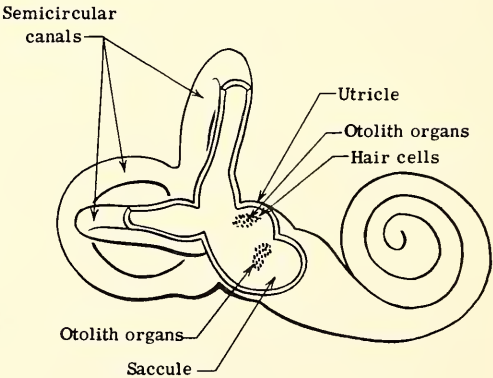


FIGURE 37

organs

773. In Figure 37, we see a diagram of the utricle and saccule. These structures contain otolith _____.

vestibular

774. Otolith organs look like small stones or crystals. They function in connection with the _____ sense.

otolith

775. Inside the two structures called the UTRICLE and the SACCULE one finds _____ organs.

otolith organs 776. Inside the utricle and saccule is a kind of fluid or gelatin. Hence, since they are also inside the utricle and saccule, the _____ are embedded in this fluid or gelatin-like substance.

saccule 777. In Figure 37, we see that the otolith organs within the utricle and the _____ are close to tiny hair cells.

hair 778. The tiny _____ cells connect to small nerve fibers which join a larger nerve that runs to the brain.

utricle 779. The otolith organs within the saccule and _____ are embedded in a fluid-like substance, and are in close contact with hair cells.

hair 780. These _____ cells, in turn, connect to small nerve fibers which join a larger nerve. The larger nerve
brain eventually runs to the _____.

utricle; otolith 781. When there are changes in pressure of the fluid within the saccule and _____, the _____ organs exert pressure against the hair cells.

hair cells 782. When the otolith organs exert pressure on the _____, nerve impulses are generated.

nerve fibers 783. The nerve impulses are then transmitted to the
brain tiny _____ connected to the hair cells and eventually find their way to the _____.

784. We can thus see that the following events occur with regard to the utricle and saccule:

fluid/gelatin 785. First, when changes in the pressure of the
otolith _____ occur, this change in pressure is exerted against the _____ organs.

otolith organs 786. Second, when the change in pressure is passed on to the _____, they in turn exert pressure against the hair cells.

hair cells 787. Third, when the _____ receive the change in pressure from the otolith organs,
nerve impulses they are activated to set off _____.

utricle 788. The semi-circular canals contain receptors that
saccule respond to changes in motion, but the _____ and _____ contain receptors that respond to changes in position of the head.

fluid/gelatin 789. For example, if you tilt your head, you change the pressure of the _____ within the utricle and saccule.

otolith organs 790. This change of pressure in the fluid causes the _____ to exert pressure on the
nerve impulses hair cells, and _____ are generated.

position/plane 791. When you lie down to go to sleep, the events that we have just described "tell" you that your body is in a horizontal _____.

position 792. In an old experiment, the vestibular mechanism, including the utricle and saccule, was removed from a frog. It was then observed that the frog swam upside down about as frequently as he swam right side up. In other words, without the mechanisms within the utricle and saccule, an organism does not "know" what his _____ in space is (unless, of course, he uses other senses such as vision).

saccule 793. We can thus see that the semi-circular canals have certain functions that are similar to those of the utricle and the _____.

fluid 794. For one thing, the semi-circular canals, and the utricle and saccule, all contain a gelatin or _____.

795. For another, they all contain tiny receptor cells that are immersed in the fluid. These receptor cells are called _____.

796. Also, the _____ of the fluid inside them changes with activity of the head.

797. And in each case, as the pressure of the fluid changes, the hair cells are activated, whereupon _____ are generated.

798. Furthermore, the nerve impulses generated by the hair cells in both the semi-circular canals and in the utricle and saccule are transmitted from the hair cells along tiny nerve fibers and thence to the brain along the _____.

799. In addition to the similarities, however, there are, of course, certain differences. Among these differences is the fact that the _____ and _____ contain otolith organs, whereas this is not so for the _____.

800. Furthermore, the _____ respond to increases and decreases in the speed with which the head moves.

801. Changes in the position of the head, however, activate the _____ and the _____.

802. We thus know when we are increasing and decreasing our speed due to the functioning of the _____, but we know the position of our head in space due to the functioning of the _____ and the _____.

803. The combined functioning of the semi-circular canals and the utricle and saccule constitute the _____ sense.

vestibular 804. Let us now summarize the above information on the _____ sense.

✓ The Semi-circular Canals:

*semi-circular
canals* 805. Event No. 1: If the body changes speed of movement in any direction, pressure increases in the fluid within the three _____.

*pressure
three* 806. Event No. 2: The change of _____ in the fluid within the _____ semi-circular canals informs us of this change of speed in our movement relative to each of the three planes.

hair cells 807. Event No. 3: The pressure changes of the fluid activate _____ that generate nerve impulses.

nerve impulses 808. Event No. 4: The _____ are then conducted along nerve fibers to the auditory nerve.

*auditory nerve
brain* 809. Event No. 5: The nerve impulses are then conducted along the _____ to the _____.

The Utricle and Saccule:

utricle; saccule 810. Event No. 1: When the head is tilted, there is a change in pressure of the fluid within the _____ and _____.

otolith 811. Event No. 2: This change in pressure causes the _____ organs, embedded in the fluid of the utricle and saccule, to exert pressure against hair cells.

*hair cells
nerve impulses* 812. Event No. 3: Pressure exerted by the otolith organs on the _____ causes _____ to be generated.

813. Event No. 4: The nerve impulses are then conducted along tiny nerve fibers that join the large _____.

auditory nerve

814. Event No. 5: The nerve impulses are further conducted along the auditory nerve to the _____, and thus one is informed of the _____ of his head in space.

*brain
position*

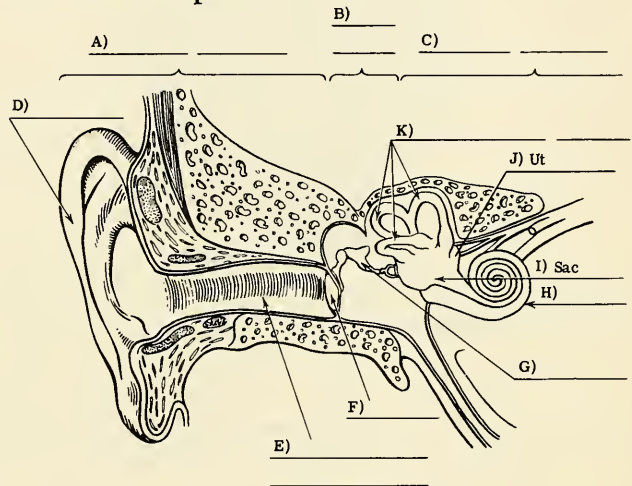


FIGURE 38

815. Label the parts in the blanks provided in Figure 38.

- A. External Ear
- B. Middle Ear
- C. Inner Ear
- D. Pinna
- E. Auditory Canal
- F. Eardrum
- G. Ossicles
- H. Cochlea
- I. Saccule
- J. Utricle
- K. Semi-circular Canals

816. Without looking at the previous discussion, state each step by which the vestibular sense informs us of our movements and position in space.

THE NERVOUS SYSTEMS

Section IX: The Neuron and the Nerve Impulse

817. You will recall our plan to investigate the biological basis of behavior in three general steps. These were to study the functions of: 1) the receptors, 2) the nervous systems, and 3) the effectors. In the preceding sections we have discussed the first step—how the _____ function.

receptors

818. We have considered ten different receptor processes. In each case we have traced the process by which a stimulus object, or event, activates a receptor to set off a _____ that is conducted to the brain.

nerve impulse

819. In this elementary coverage, many interesting matters have necessarily been left for your future study. What we have tried to do is show how the different receptors are _____ to _____ send nerve impulses to the _____.

*activated/
stimulated/excited
brain*

820. We will now consider how these _____ are transmitted from the receptors through the nervous systems (including the brain and spinal cord) to the effectors.

*nerve
impulses*

821. The NERVOUS SYSTEMS, including the spinal cord and the brain, are composed of NERVES. It now remains for us to be more precise about the nature of these _____ that make up the nervous systems.

nerves

nerve 822. Actually a _____ is a very complex structure that is made up of a large number of “tiny nerves” called NEURONS. A nerve is thus a group, or
neurons collection, of _____.

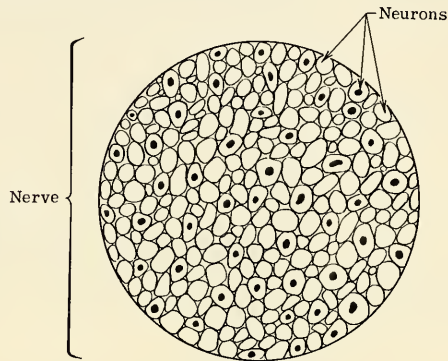


FIGURE 39

823. In Figure 39, we see a cross section of a nerve. You can see that the nerve is made up of a large number of _____.
neurons

824. A nerve is a bundle, group, or collection of “tiny nerves” called _____.
neurons

825. Which is larger: a neuron or a nerve?
nerve A _____.

826. A _____ is larger than a _____.
nerve; neuron

827. We previously said that nerve impulses are conducted along nerves. Now we can be more precise and say that _____ are conducted along the neurons within a nerve.
nerve impulses

828. _____ are tiny nerves that _____ nerve impulses.
Neurons
conduct/transmit

829. A number of nerve impulses can be conducted simultaneously within a given nerve. This is so because each _____ contains a large number of _____.
nerve
neurons

nerve impulses

830. A nerve impulse is conducted along a neuron that is contained within a nerve. Because each nerve contains a large number of neurons, we can see that a large number of _____ can be conducted within a nerve at any given time.

neuron

831. It is important for us to study the nature of a nerve impulse that is conducted along a _____ within a nerve.

conducts/transmits

832. To understand the nature of neural conduction we should study the structure of the neuron, because it is the neuron, itself, that _____ nerve impulses.

*absolute threshold
activated/excited*

833. Recall that when a stimulus which is above the _____ impinges on a receptor, that receptor is _____ to set off nerve impulses.

neurons

834. The nerve impulses so generated are then conducted along _____ within a nerve and usually end up in the brain.

effectors

835. The nerve impulses are then conducted from the brain to effectors or, more precisely, to one of the two types of _____ called muscles and glands.

brain

836. Effectors may receive nerve impulses from the _____.

muscles; glands

837. Once a nerve impulse leaves the brain, it may run to one of the two types of effectors called _____ and _____.

*receptor
nerve impulse*

838. We thus have a general overview of neural conduction: When a stimulus impinges on an organism, a _____ is activated whereupon a _____ is generated.

839. The nerve impulse is then conducted along a series of neurons to the _____.

brain

840. Eventually the nerve impulse leaves the brain and runs to one of two types of _____.

effectors

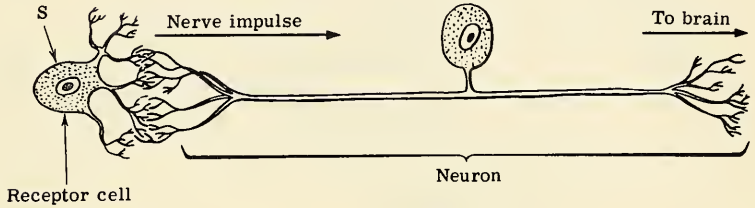


FIGURE 40

841. In Figure 40, we see a representation of the first part of this process. The stimulus (S) impinges on a _____ cell, and this action generates a nerve impulse.

receptor

842. Note, in Figure 40, how the receptor cell connects to, or makes junction with, a neuron. Hence, the nerve impulse is transmitted from the receptor cell to the _____ and then eventually to the _____.

neuron; brain

843. Because there are a large number of receptor cells in the organism that make junction with a large number of neurons, and because a large number of stimuli are constantly impinging on the organism, we can see that a _____ number of nerve impulses are constantly being conducted to the brain.

large

844. Any organism is constantly being activated by the numerous stimuli in its _____.

environment

845. These stimuli are continually activating receptor cells so that numerous nerve impulses are being conducted along the _____ contained within the nerves that run to the brain.

neurons

846. Let us now look more closely at the structure of a neuron.

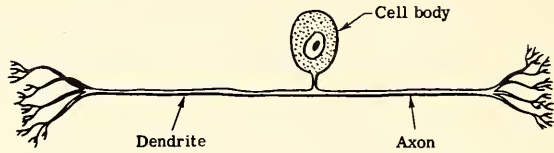


FIGURE 41

847. In Figure 41, we note that there are **THREE** *three* MAJOR parts of a neuron. These _____ major parts are 1) the CELL BODY, 2) the DENDRITE, and 3) the *axon* _____.

848. There are _____ parts to each *three neuron* _____.

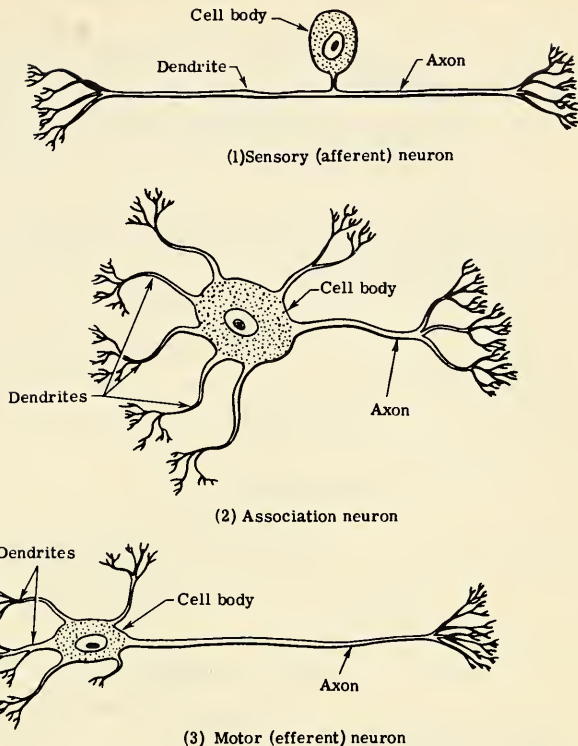
849. Every neuron has a CELL BODY. It is the *cell* _____ body that "feeds" or "nourishes" the neuron and thus "keeps it alive."

850. If a neuron did not have a _____ *cell body* _____ it would die.

851. In addition to the part of the neuron called the *cell body* _____, every neuron has one or more DENDRITES, and one, but only one, axon.

852. The dendrite is always on one side of the cell body, whereas the *axon* _____ is always on the other side.

853. Although a neuron has more than one dendrite, *axon* it can only have one _____.

**FIGURE 42**

854. In every neuron there is one axon, but there may be several .

dendrites

855. Neurons vary considerably in their shape and size. In Figure 42, you can observe three different types of neurons. In each example, note the various arrangements of the axon, the dendrites, and the .

cell body

856. The neurons that occur in the body may be classified into the three types shown in Figure 42. The first type is the **SENSORY**, or **AFFERENT**, neuron, and is typically distinguished by the fact that the and dendrite are relatively long.

axon

857. Note also, that in the sensory, or afferent, neuron, the cell body projects up from the dendrite and .

axon

858. The type of neuron in which the axon and _____ are both relatively long, and in which the cell body projects up from them, is known as the sensory or _____ neuron.

dendrite

afferent

859. In the afferent neuron, the axon and _____ are quite long.

dendrite

860. Study Figure 42 and note the long axon and _____ of the sensory, or _____ neuron.

dendrite; afferent

861. Because it is close to the receptor that receives SENSORY information (stimuli) from the organism's environment, the afferent neuron is also known as the _____ neuron.

sensory

862. Hence, when a receptor receives stimulation from the environment, it transmits a nerve impulse to an _____ neuron.

afferent/a sensory

863. The type of neuron that receives a nerve impulse from a receptor, and transmits it TOWARD the spinal cord and brain, is known as an _____ neuron.

afferent/a sensory

864. *Af* derives from the Latin, meaning TOWARD, or TO. Hence, afferent neurons conduct nerve impulses _____ the brain.

toward/to

865. There are three types of neurons. The type of neuron that conducts nerve impulses toward the brain is called the _____ neuron.

afferent

866. When a stimulus object excites a receptor, a nerve impulse is generated. That nerve impulse is then conducted along an _____ neuron _____ the brain.

afferent

toward/to

867. In contrast to the afferent neuron, which conducts _____ toward the brain, there is the MOTOR, or EFFERENT neuron, which is number _____ in Figure 42.

nerve impulses
three (3)

868. Whereas the afferent neuron conducts impulses toward the spinal cord and brain, the efferent, or motor neuron, conducts nerve impulses away from, or out of, the spinal cord and _____.

brain

869. In Figure 42, you can see that the efferent or _____ neuron has a number of _____, but only one axon.

motor
dendrites

870. Motor, or _____ neurons have a number of dendrites.

efferent

871. Like all neurons, EFFERENT neurons have only one _____.

axon

872. Study the efferent neuron in Figure 42. The dendrites of the _____ neuron are quite short, but the _____ is typically very long.

efferent/motor
axon

873. In the efferent neuron, the _____ are short.

dendrites

874. Whereas the dendrites are short in the efferent neuron, the _____ is usually long.

axon

875. The efferent neuron usually has several short _____ but a long _____.

dendrites; axon

876. The afferent neuron has a _____ dendrite and axon.

long

877. The dendrite of the afferent neuron is typically longer than the dendrites of the _____ neuron.

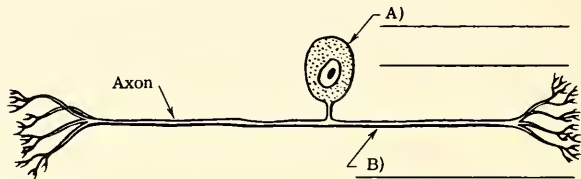
efferent

- efferent

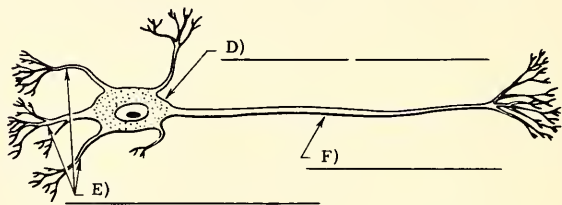
afferent

878. The _____ neuron has shorter dendrites than the _____ neuron.
- efferent/motor;
neuron
out

879. The EF of Efferent is derived from the Latin, meaning OUT. Hence, the _____ conducts nerve impulses away from, or _____ of, the brain and spinal cord.



C) This is an _____ neuron



G) This is an _____ neuron

FIGURE 43

880. In Figure 43, you see two types of neurons. Write the parts of these neurons, and indicate which type they are, in the blanks furnished.

- A. Cell Body
- B. Dendrite
- C. Afferent/Sensory
- D. Cell Body
- E. Dendrites
- F. Axon
- G. Efferent/Motor

- efferent

nerve (neural)

impulses

881. Whereas afferent neurons receive nerve (neu-
ral) impulses from receptors, _____
neurons send _____ to
the muscles and glands.
- axon

dendrites

882. The efferent neuron has one very long _____
and a number of short _____.

883. Efferent neurons transmit nerve impulses from, or out of, the brain and spinal _____ to the two types of effectors: _____ and _____.

*cord
muscles; glands*

884. The third type of neuron found in the body is known as the ASSOCIATION neuron. It is in the BRAIN and SPINAL CORD that we find the _____ neuron.

association

885. Refer to Figure 42. As you see, the association neuron is quite different in shape from the _____ and _____ neurons.

*afferent; efferent
(either order)*

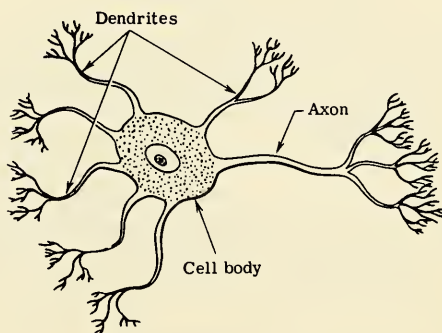


FIGURE 44

886. In Figure 44, we see a diagram of an _____.

association neuron

887. As you can see, there is one _____ but a number of _____ in the _____ neuron.

*axon
dendrites;
association*

888. Afferent and efferent neurons are found in the body outside of the BRAIN and SPINAL CORD, but association neurons are found only inside, or within the _____ and _____.

brain; spinal cord

889. The type of neuron found inside the brain and spinal cord is the _____ neuron.

association

afferent; efferent 890. On the other hand, the types of neurons found in parts of the body OUTSIDE of the brain and spinal cord are the _____ and _____ neurons.

inside/within 891. Association neurons are located _____
afferent the brain and spinal cord, whereas _____
efferent and _____ neurons are located in parts
(either order)
outside of the body _____ the spinal cord and brain.

nerve 892. Afferent neurons transmit _____
impulses _____ toward the spinal cord and brain.

association 893. Within the spinal cord and brain we find _____ neurons.

association 894. Therefore, when a nerve impulse leaves an afferent neuron, it is received within the spinal cord, or brain, by an _____ neuron.

toward/to 895. When an afferent neuron transmits a nerve impulse _____ the brain, it is received by an association neuron.

association 896. Nerve impulses are received within the spinal cord and brain by _____ neurons.

association 897. Let us consider one of the simplest possible arrangements of neurons: The case when an afferent neuron transmits a nerve impulse to an association neuron. The _____ neuron, in turn, transmits the impulse to an efferent neuron.

association 898. The three different types of neurons act together. Thus, the afferent and the efferent neurons are linked together, or ASSOCIATED, by means of an _____ neuron.

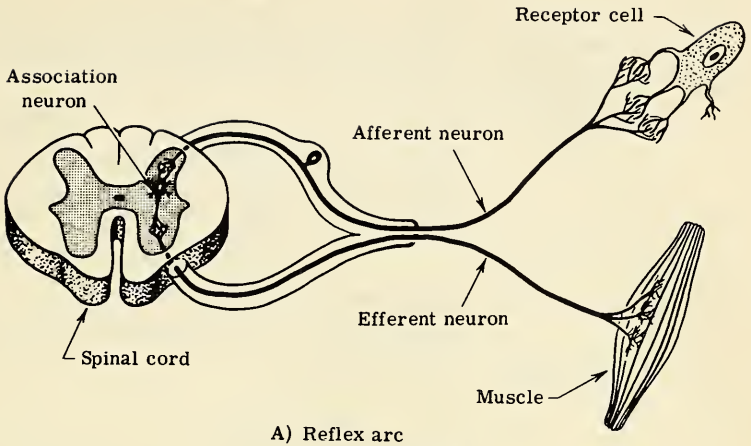


FIGURE 45

899. In Figure 45, we see an example of how these three different types of neurons work together. First, the *afferent* _____ neuron receives an impulse from a receptor.

900. This impulse is transmitted from the afferent *association neuron* to an _____ which, in turn, sends the impulse to an efferent neuron.

901. When the association neuron transmits the impulse to the *efferent* _____ neuron, the impulse goes to an effector.

902. The arrangement of the three neurons, shown in Figure 45, is known as a REFLEX ARC. A series of an afferent neuron, an association neuron, and an efferent neuron, working together to conduct a nerve impulse, is called a *reflex* _____ arc.

903. When a nerve impulse is conducted along an afferent neuron into the spinal cord, is received by an association neuron, and conducted out of the spinal cord along an efferent neuron, we have an example of a *reflex* _____ arc.

904. A simple reflex arc involves the three types of *nerve* neurons working together to conduct a *impulse* _____.

905. Actually we have oversimplified this matter, for seldom would we find just a single association neuron in a reflex arc.

association 906. Rather, a number of _____
neurons usually connect an afferent and an efferent
reflex arc neuron to form a _____.

907. A reflex arc is a series of neurons that work together to conduct a nerve impulse. For example, if you touch a hot stove, the HEAT and PAIN receptors in your fingers would generate _____ *nerve impulses* _____.

908. These nerve impulses would then be received by *association* afferent neurons, transmitted to _____ neurons, and then along _____ neurons to effectors.

909. When the nerve impulse leaves the efferent *effectors/muscles* neuron and finally arrives at these _____ in your fingers and arms, you withdraw your hand from the hot stove.

910. The activation of a series of neurons that form a *reflex arc* _____ requires but a fraction of a second. Think how fast you can withdraw your hand from a hot stove.

911. We thus can see that, in the case of a reflex arc, a neural impulse is very quickly conducted into, through, and back out of the spinal cord to an *effector* _____.

nerve impulses 912. We previously said that afferent neurons conduct _____ toward the brain.

913. We thus can see that neural impulses, which enter the spinal cord, can go in two directions: 1) to the brain, and 2) back out of the spinal cord along an neuron to an effector.

efferent

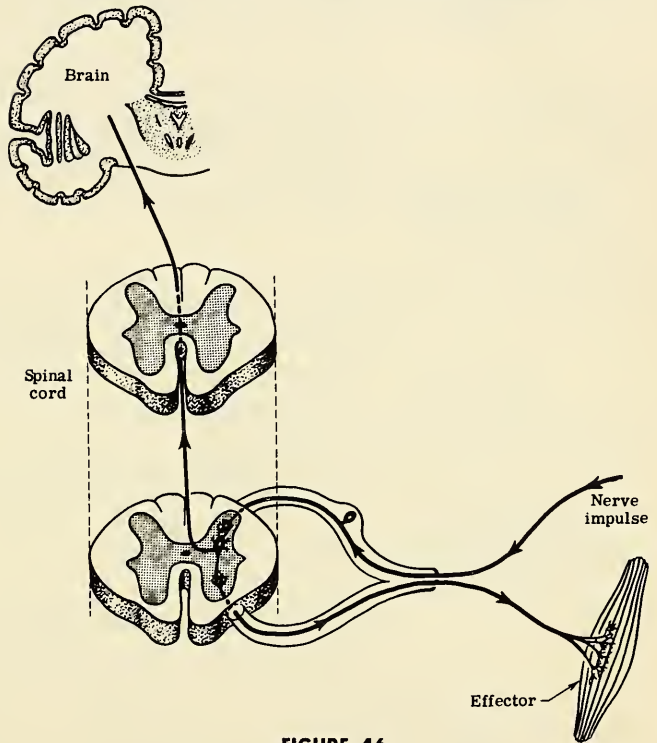


FIGURE 46

914. In Figure 46, we show a reflex arc. You can see that once the neural impulse enters the spinal cord, it may be simultaneously transmitted to an effector and up the spinal cord to the .

brain

915. Neural impulses that enter the spinal cord may go in two directions: 1) up the spinal cord to the , and 2) immediately back out of the spinal cord to an .

*brain
effector*

916. When a neural impulse is conducted along an afferent neuron, it is referred to as an AFFERENT NEURAL IMPULSE. Hence, an afferent neural impulse is one that is conducted the brain and spinal cord.

toward/to

917. After an afferent neural impulse enters the spinal cord, it may go in two directions: 1) up the *brain* spinal cord into the _____, and 2) back out of the spinal cord along an efferent neuron and finally to an *effector* _____.

918. An afferent NEURAL impulse is so named because it is conducted along an afferent neuron. You can now guess that a nerve impulse conducted along an efferent neuron is called an *efferent neural (or nerve) impulse* _____.

919. The difference between an afferent and an efferent neural impulse is that the afferent impulse is conducted _____ the brain, whereas an efferent impulse is conducted _____ from the brain. *toward/to away/out*

920. Recall that every neuron has three major parts: the *cell body; dendrites; axon (either order)* _____, the _____, and the _____.

921. Think of a reflex arc, and imagine a nerve impulse running along the afferent neuron, then along the *association* _____ neuron, and finally, to the point at which it is transmitted from the association neuron to the *efferent* _____ neuron.

922. Now focus on the part of the reflex arc where the nerve impulse is transmitted from the association neuron to the *efferent* _____ neuron.

923. Which part of the efferent neuron receives the *nerve impulse* _____?

924. Does the efferent neuron receive the nerve impulse at its cell body, at its axon, or at its *dendrites* _____?

925. The efferent neuron may receive the *nerve impulse* _____ at either its cell body or at its dendrites.

926. In general, two parts of a neuron may receive a nerve impulse. These are 1) the dendrites, and 2) the cell body. Thus, when a neuron is conducting a nerve impulse, we know that it received that nerve impulse at either its dendrites or at its _____.

cell body

927. A neuron may receive a nerve impulse from either a receptor, or from another neuron. In either case, that nerve impulse was received by that neuron at its _____, or at its _____.

cell body; dendrites

928. If a nerve impulse is picked up by the dendrites, it is conducted past the cell body to the third part of the neuron called the _____.

axon

929. If the nerve impulse, however, is received directly by the cell body, it is transmitted to the axon, thus bypassing the _____.

dendrites

930. Whenever a nerve impulse is transmitted along an axon, it is typically passed on to an effector or to another _____.

neuron

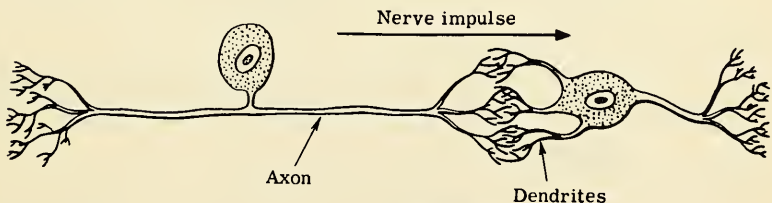


FIGURE 47

931. In Figure 47, we see a representation of a nerve impulse passing from the axon of one neuron to the _____ of a second neuron.

dendrites

932. Although a nerve impulse may be received by the dendrites, or by the _____ of a neuron, it is never received by the _____ of a neuron.

cell body

axon

933. In normal functioning, a neuron never receives a nerve impulse by means of its _____.

axon

axon/cell body 934. Conduction of the nerve impulse is normally in one direction only—from the dendrites toward the _____.

neurons 935. Let us now summarize what we have said to this point. Nerves are bundles of _____.

✓
cell body; axon;
dendrites
(either order) 936. Every neuron has three major parts. These are the _____, the _____ and the _____.

neurons 937. Nerve impulses are conducted along _____
nerve within a _____.

afferent 938. There are three types of neurons within the
association body. These are the _____ neuron,
efferent the _____ neuron, and the
(any order) _____ neuron.

afferent 939. When a nerve impulse is conducted along an
neural afferent neuron, it is called an _____
 _____ impulse.

efferent neural 940. When an impulse is conducted along an efferent
impulse neuron, it is called an _____
 _____.

reflex arc 941. When a nerve impulse is transmitted along an afferent neuron, through the spinal cord by means of an association neuron, and back out of the spinal cord along an efferent neuron, we have an example of a _____.

axons 942. Afferent neurons have relatively long _____
dendrites and _____
(either order)

cell body 943. In the afferent neuron, the _____
 projects up from the dendrites and axon.

944. Afferent neurons receive nerve impulses from _____ and conduct them _____ the spinal cord and brain.
945. Association neurons receive nerve impulses from _____ neurons.
946. The association neuron, like all neurons, receives nerve impulses at its _____ or at its _____.
947. No neuron ever receives a nerve impulse at its _____.
948. When a nerve impulse enters the spinal cord, it is received by an _____ neuron, which may then send the impulse to the brain and also out of the spinal cord along an _____ neuron, and then to the effectors.
949. Once a nerve impulse arrives in the spinal cord it may thus go back out to an effector, and also up the _____.
950. The efferent neuron has only one axon, but a number of _____.
951. The efferent neuron has a number of short _____, but the _____ is very long.
952. Like all neurons, two parts of an efferent neuron may receive a nerve impulse. These are the _____ and the _____.
953. An efferent neuron never receives a nerve impulse at its _____.
954. With this general understanding, let us now look more closely at how the neuron conducts a _____.

receptors; toward

afferent

*dendrites
cell body*

axon

association

efferent

brain

dendrites

dendrites; axon

dendrites; cell body

axon

nerve impulse

THE NERVOUS SYSTEMS

Section X: Electrical and Chemical Aspects of the Nerve Impulse

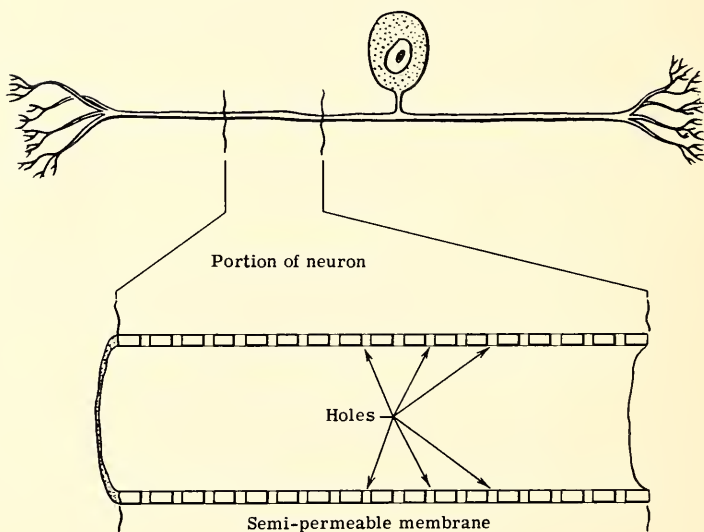


FIGURE 48

955. Consider that we take a portion of a neuron, such as that shown in Figure 48, and magnify it in size. The bottom part of Figure 48 shows that the neuron has a SEMI-PERMEABLE MEMBRANE.

956. A membrane is a very thin sheet of tissue. The semi-permeable membrane, in Figure 48, is a very thin sheet of tissue that covers the neuron.

957. A membrane covers the outside of a neuron. This cover is called a semi-permeable membrane.

958. Note the small holes in the bottom of Figure 48.
membrane A semi-permeable _____ covers the neuron and has small holes in it.

959. The outside, or cover, of a neuron, called a semi-permeable membrane, has small _____ in it.

960. Later we shall see why we call this membrane a semi-permeable one. For now, however, simply note that we call the cover of a neuron a _____ membrane because it has small holes in it.

961. Every neuron is covered with a thin sheet of tissue called a _____.

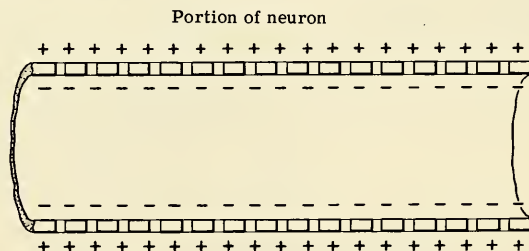


FIGURE 49

962. Figure 49 shows a portion of a _____ in its normal resting state.

963. Note the small pluses on the outside of the semi-permeable membrane, and the small minuses inside the _____.

964. The plus and minus signs stand for IONS (i'onz). An ion is an electrically charged atom. Figure 49 indicates that the neuron has electrically charged atoms called _____.

965. The plus signs, in Figure 49, stand for positive ions, and the minus signs stand for negative ions. For our purposes, we may think of a positive _____ as an atom with a positive charge of ELECTRICITY.

966. The plus, or positive, signs, in Figure 49, represent _____ ions.

positive

967. A positive ion is an atom with a plus, or positive, charge of _____.

electricity

968. If a positive ion is an atom with a positive charge of electricity, then a negative ion is an atom with a _____ charge of electricity.

negative/minus

969. In its NORMAL RESTING STATE, the neuron has _____ ions on the outside of its _____ membrane.

*positive
semi-permeable*

970. The inside of the _____ has _____ ions.

*semi-permeable
membrane; negative*

971. The positive charges of electricity on the outside of the semi-permeable membrane, "balance" (in a sense) the negative charges on the inside. This BALANCE exists when the neuron is in a normal _____ state.

resting

972. During the normal resting state of the neuron, the neuron is just "resting"—a nerve impulse is _____ being conducted.

not

973. When a neuron is in its normal resting state, a balance exists between the _____ on the outside of the semi-permeable membrane and the _____ inside the semi-permeable membrane.

*positive
ions
negative ions*

974. An atom that is positively charged with electricity is called a _____ ion, whereas an atom that is negatively charged with _____ is called a _____.

*positive
electricity; negative
ion*

975. The negative ions on the inside of the semi-permeable membrane balance the positive ions on the _____ when the neuron is in its normal resting state _____.

976. Let us now see what happens when this _____ balance between the positive and negative ions is disturbed.

977. If the neuron is in its normal resting state when a balance exists between the positive and negative ions, the neuron stops being in its _____ normal resting state _____ when that balance is disturbed.

978. The disturbance of the balance between the positive ions on the _____ of the semi-permeable membrane and the _____ outside negative ions _____ on the inside of the semi-permeable membrane removes the neuron from its normal resting state.

979. When a balance exists between the positive and negative ions, the neuron is in its normal resting state and it, therefore, is not conducting a _____ nerve impulse _____.

980. However, when this balance is disturbed, a neuron starts to _____ conduct/transmit a nerve impulse.

981. A nerve impulse starts to be transmitted along a neuron when the balance between the _____ positive semi-permeable membrane negative _____ ions on the outside of the _____ cease to balance the _____ ions on the inside.

982. Let us now see more precisely what happens when a neuron conducts a _____ nerve impulse _____.

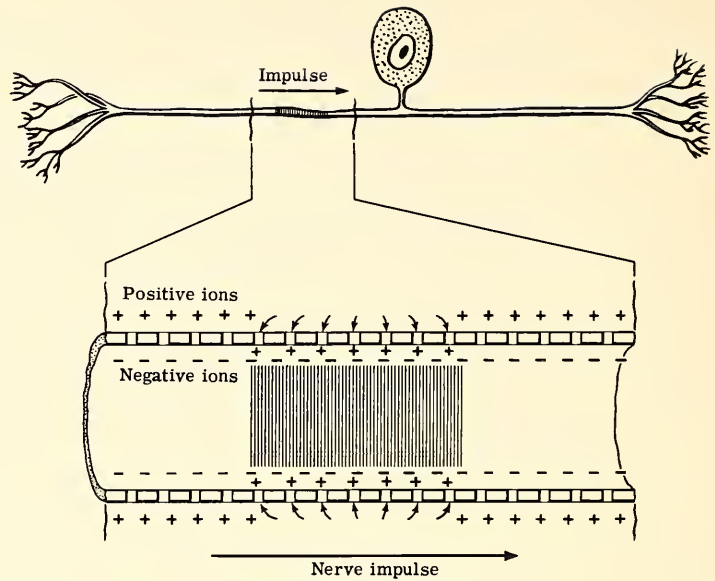


FIGURE 50

983. At the top of Figure 50, the shaded portion of the neuron indicates a nerve impulse traveling along it. A close-up view is shown at the bottom of the figure. The arrows indicate that the _____ ions are moving from the outside to the inside of the semi-permeable membrane.

984. In other words, when a nerve impulse is conducted along a neuron, positive charges of electricity move through the holes to the inside of the _____.

985. The passage of a nerve impulse along a neuron disturbs the balance between positive and negative ions that exists during the resting state. The disturbance of this balance occurs as the _____ move to the _____ of the semi-permeable membrane.

986. As the nerve impulse moves along the neuron, positive ions continue to move _____.

987. That is, the movement of positive ions, in one region of the neuron, causes the _____ in the next (neighboring) region to also move inside.

988. It is the movement of positive ions to the inside of the semi-permeable membrane that disturbs the _____ that exists during the normal resting state.

989. As the nerve impulse moves along the neuron, the balance in each succeeding section of the neuron is disturbed when _____ move inside.

990. When a neuron is conducting a nerve impulse, the balance between the positive and negative ions is disturbed, and, at that time, the neuron ceases to be in its normal _____.

991. We previously said that a neuron receives a nerve impulse at its dendrites or at its _____.

992. Just prior to the receipt of that nerve impulse, the neuron is in its normal _____.

993. Let us say that the neuron receives a nerve impulse at its cell body. The entrance of the nerve impulse disturbs the balance in the cell body that exists between the positive and _____ ions in that region of the neuron.

994. When the balance in the cell body is disturbed, the positive ions start to move to the _____ of the semi-permeable membrane.

995. Once the positive ions in the cell body start to move to the inside, this disturbance is passed on to the next region of the neuron. That is, after the positive ions in the cell body move inside, the *positive ions* _____ in the first part of the axon also start to move inside.

996. Eventually, then, all of the rest of the positive ions on the outside of the semi-permeable membrane, *inside* in the region of the axon, also move to the _____.

997. In this manner, the nerve impulse that entered at the cell body is conducted through the cell body *axon* and along the part of the neuron called the _____.

998. Note that when a nerve impulse is received in the cell body, the disturbance of the balance is transmitted directly to the axon, thus by-passing the *dendrites* _____.

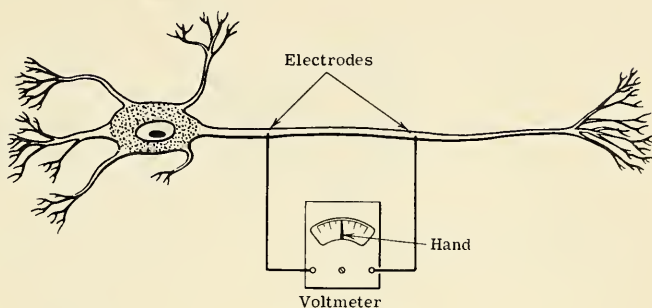
999. If, however, the dendrites receive the nerve impulse, it is conducted along the dendrites, through *axon* the cell body, and finally along the _____.

1000. That is, a nerve impulse received at the dendrites causes the positive ions, in all parts of the neuron, to move to the inside of the *semi-permeable membrane* _____.

1001. Let us now study further the electrical aspects of a nerve impulse. Note that an ELECTRODE is essentially a tiny wire. These tiny wires, known as *electrodes* _____, may be inserted into a neuron.

1002. Tiny wires inserted into a neuron are called *electrodes* _____.

1003. To study the electrical aspects of a nerve impulse the tiny wires, or *electrodes* _____, can then be connected to a VOLTMETER.

**FIGURE 51**

1004. A voltmeter is a device that measures amounts of electricity. Note, in Figure 51, that the hand of the *voltmeter* _____ is represented by an arrow.
1005. The hand of the *voltmeter* _____ moves to indicate the amount of electricity being generated by the nerve impulse.
1006. In Figure 51, you can see that two electrodes are inserted into a neuron. A voltmeter is then connected to these two *electrodes* _____.
1007. When a nerve impulse is conducted along a neuron, electricity is generated. The amount of this electricity can be measured by a device called a *voltmeter* _____.
1008. That is, when a *nerve impulse* _____ flows along a neuron, electricity will flow along the attached electrodes.
1009. When the electricity reaches the voltmeter, it causes the hand of the *voltmeter* _____ to move.
1010. Thus, by observing the movement of the *hand* _____ of the voltmeter, we can measure the amount of electricity generated when a *nerve impulse* _____ is conducted along a neuron.

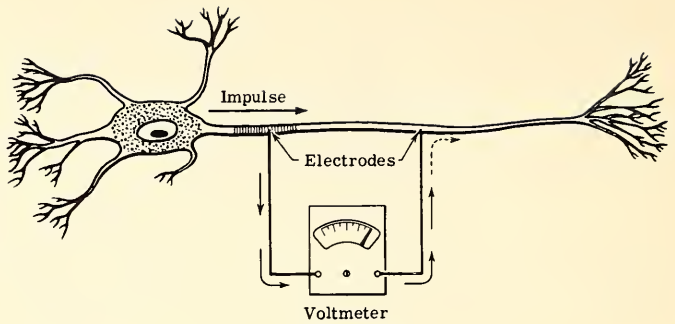


FIGURE 52

1011. Observe, in Figure 52, that when a nerve impulse flows along a neuron, electricity flows along the attached electrodes. When this _____ reaches the voltmeter, it causes the hand of the _____ to move.

1012. The amount of movement of the hand of the _____ electricity voltmeter indicates how much _____ is flowing through the neuron.

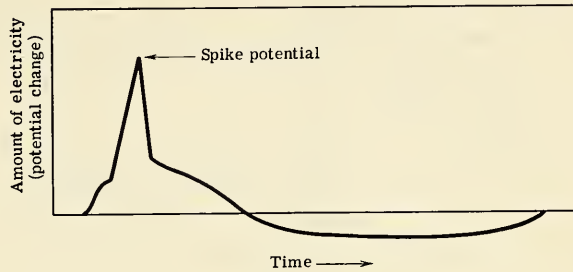
1013. By recording the movement of the hand, we can measure the amount of electricity generated by the _____ nerve impulse _____ as it moves along the neuron.

1014. In order to measure the amount of electricity generated by a nerve impulse, we first insert two tiny wires called _____ electrodes _____ into a neuron.

1015. The electrodes are then attached to a device that measures amount of electricity. This device is called a _____ voltmeter _____.

1016. As a nerve impulse is conducted along a neuron, the electricity thereby generated will flow through the electrodes and cause the hand on the _____ voltmeter _____ to move.

1017. The amount of movement of the hand indicates the amount of _____ electricity _____ generated by the nerve impulse.

**FIGURE 53**

1018. In Figure 53, you can observe how much *electricity* _____ is generated as the nerve impulse passes any given point.

1019. Note that the vertical axis is labeled "Amount of _____."

1020. Also note that the horizontal axis is labeled "_____."

1021. Thus, by studying Figure 53, we can tell the *electricity* amount of _____ given off by a nerve impulse at any given time.

1022. That is, when the curve, shown in Figure 53, is very high, a large amount of electricity is generated, but when the curve is low, only a small *amount* _____ of electricity is generated.

1023. Note, in Figure 53, that a small "bump" occurs just before the very large spike potential. This small bump indicates that, before the spike potential occurs, only a *small* _____ amount of electricity is generated by the nerve impulse.

1024. The amount of electricity initially given off by a nerve impulse is very *small* _____.

1025. After this small amount of electricity is generated, the *spike* **SPIKE POTENTIAL** occurs. The _____ potential occurs after an initial small amount of electricity is generated.

1026. As you can see in Figure 53, a very large amount of electricity is given off when the spike potential _____ occurs.

1027. When the main part of a nerve impulse passes a given point on the neuron, a very large amount of electricity is measured by the voltmeter. This very large amount of electricity is called the _____ spike potential.

1028. The largest amount of electricity is given off when the spike potential _____ occurs.

1029. Now observe, in Figure 53, that another small bump occurs immediately after the spike potential. After the _____ occurs, an additional, but smaller, amount of electricity is given off.

1030. By studying Figure 53, we can thus see how much electricity is generated when a _____ nerve impulse _____ passes any given point on a neuron.

1031. Thus, when we insert an electrode in a certain point on a neuron, we can measure the amount of _____ electricity given off as the nerve impulse passes that point.

1032. When a nerve impulse passes the point at which we have inserted an electrode, at first a very _____ small amount of electricity is generated.

1033. Next, a very large amount of electricity is then generated. We call this large amount of electricity the _____ spike potential _____.

1034. Then, immediately following the spike potential, additional electricity flows, but this time it is _____ small _____ in amount.

1035. You can thus see that the electrical aspects of a nerve impulse consists of: first, the generation of a small amount of electrical flow, followed by the generation of a major amount, which constitutes the _____, following which an additional small amount of electricity flows.

spike potential

1036. Figure 53 shows what happens when a single nerve impulse is conducted along a neuron. Every nerve impulse gives off one, but only one, spike _____.

potential

1037. Before a neuron conducts or "fires" a nerve impulse, it is in its normal _____ state.

resting

1038. Immediately after a neuron FIRES, it is in an "exhausted" state. Hence, the _____ needs to recharge itself before it can fire again.

neuron

1039. After a neuron conducts a nerve impulse, it is in an _____ state and cannot immediately fire again.

exhausted

1040. Hence, the neuron needs to recharge itself before it can _____ again.

fire

1041. After a neuron conducts a nerve impulse, it starts to recharge itself in order to return to its normal _____.

resting state

1042. The period immediately following the nerve impulse is known as the ABSOLUTE REFRACTORY PERIOD. Immediately after a nerve impulse passes a certain point on a neuron, that point on the neuron enters the absolute refractory _____.

period

1043. It is during the absolute _____ that the neuron is completely unable to conduct a nerve impulse.

refractory period

*absolute
refractory period*

1044. No matter how intensely a neuron is stimulated, it cannot fire during the _____.

nerve impulse

1045. After a neuron has conducted a nerve impulse, it is in an exhausted state and enters the absolute refractory period. Before the neuron can conduct another _____ it must recharge itself.

*absolute
refractory*

1046. It is during the _____ period that the neuron starts to recharge itself.

*absolute
refractory period*

1047. The absolute refractory period is the first state of recharging. The neuron continues to recharge itself during the RELATIVE refractory period, a period that immediately follows the _____.

nerve impulse

1048. When a neuron is in the absolute refractory period, it absolutely cannot conduct another _____.

*refractory
period*

1049. But once the neuron leaves the absolute refractory period and enters the relative _____, it is possible to transmit a new nerve impulse.

relative

1050. A neuron CAN fire during the _____ refractory period, provided that the stimulation is greater than normal.

greater/higher

1051. During the relative refractory period the intensity of a new nerve impulse must be _____ than normal in order for it to be conducted by the neuron.

absolute 1052. Although a neuron cannot successfully receive a new nerve impulse when it is in the _____ refractory period, it can when it is in the _____ refractory period, provided that the intensity of the entering impulse is quite high.

relative 1053. Although the neuron is not completely RECHARGED during the absolute refractory period, it is partially _____ during this period.

recharged 1054. The period immediately following the absolute refractory period is called the _____.

relative refractory period 1055. The _____ refractory period comes before the _____ refractory period.

absolute refractory period 1056. The neuron is absolutely unable to conduct a nerve impulse during the _____, but it can conduct a nerve impulse during the _____, provided that the stimulation is quite intense.

relative refractory period 1057. Once a neuron conducts a nerve impulse, it is exhausted, following which it starts to recharge itself. It is during the absolute and relative refractory periods that the neuron _____ itself.

recharges 1058. Following the completion of the relative refractory period, the neuron is returned to its normal resting state and is thus completely _____.

recharged/recovered 1059. Although a nerve impulse has ELECTRICAL aspects, it also has CHEMICAL aspects. We have considered some of the electrical characteristics of a nerve impulse, so let us now turn to a brief consideration of some of its _____ characteristics.

chemical

semi-permeable 1060. In the resting neuron, small chemical particles, called SODIUM IONS, exist on the outside of the _____ membrane.

sodium 1061. You eat sodium ions every day in your table salt. In the resting state the ions that tend to concentrate on the outside of the semi-permeable membrane are called _____ ions.

ions 1062. When the neuron is at rest, sodium _____
outside are primarily on the _____ of the semi-permeable membrane.

outside 1063. Whereas sodium ions are concentrated on the _____ of the semi-permeable membrane, during the resting state, the ions concentrated on the
ions inside are called potassium _____.

inside 1064. During the resting state, potassium ions are concentrated _____ the semi-permeable membrane.

potassium 1065. The name of the ion that is concentrated inside the semi-permeable membrane, during the resting state, is the _____ ion.

outside 1066. In the resting neuron, sodium ions are concentrated _____ the semi-permeable membrane, whereas _____
potassium ions tend to concentrate inside it.

inside 1067. Potassium ions are concentrated _____
sodium the semi-permeable membrane, whereas _____
ions _____ are concentrated outside.

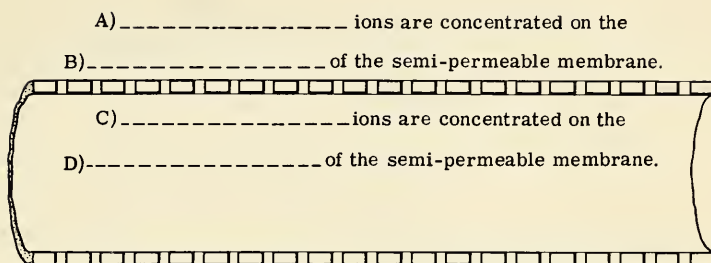


FIGURE 54

1068. In Figure 54, we see a representation of the semi-permeable membrane of a neuron in the resting state. Fill in the blanks.

- A. Sodium
B. Outside
C. Potassium
D. Inside

1069. When a nerve impulse moves along a neuron, the sodium ions move through the small holes from the _____ to the inside of the semi-permeable membrane.

1070. At approximately the same instant that most of the sodium ions have moved to the _____ of the semi-permeable membrane, the potassium ions that are inside begin to move to the _____.

1071. That is, as a nerve impulse moves along a neuron, _____ move to the inside, shortly after which potassium ions start to move to the outside of the semi-permeable membrane.

1072. It is this passage of sodium ions to the inside of the semi-permeable membrane and _____ to the outside that helps to account for the electrical aspects of a nerve impulse.

1073. The electrical aspects of a nerve impulse are largely produced by the passage of _____ ions to the inside, and of _____ ions to the outside of the semi-permeable membrane.

electrical 1074. Both chemical and _____ processes occur during the passage of a nerve impulse.

chemical 1075. When the sodium ions come in contact with the potassium ions, certain chemical events occur. These _____ events are rather complex and not very well understood.

electricity 1076. It has, however, been established that the passage of sodium ions to the inside, and of potassium ions to the outside, produces most of the _____ generated by a nerve impulse.

chemical 1077. Let us now summarize and extend our discussion of the nerve impulse. A nerve impulse has both electrical and _____ aspects.

*positive
inside* 1078. When a nerve impulse is conducted along a neuron, _____ charges of electricity move from the outside to the _____ of the semi-permeable membrane.

voltmeter 1079. We can measure the amount of electricity generated, by attaching electrodes that connect to a device called a _____.

*sodium
potassium* 1080. The chemical aspects of the nerve impulse involve the movement of _____ ions to the inside, where they come in contact with _____ ions.

*sodium
outside* 1081. As the nerve impulse moves along the neuron, at first there is a movement of the _____ ions to the inside, following which there is a movement of potassium ions to the _____.

1082. This movement of the sodium ions to the inside, and of the _____ to the outside, results in the generation of a very large amount of electricity called the _____.

potassium ions

spike potential

1083. The period immediately following the passage of a nerve impulse is called the _____ period.

absolute refractory

1084. During the absolute refractory period the neuron starts to _____ itself.

recharge

1085. It is during the absolute refractory period that the sodium ions that have previously moved to the inside, start to return to their original position _____ the semi-permeable membrane.

outside

1086. During the absolute refractory period, the _____ ions start to return to the outside of the membrane.

sodium

1087. This movement of the sodium ions to the outside continues during the period immediately following the absolute refractory period; that is, during the _____ period.

relative refractory

1088. When the relative refractory period has ended, all the sodium ions have returned to the _____ of the membrane.

outside

1089. At this point, the balance is restored and the neuron is returned to its normal _____.

resting state

1090. Once a neuron has been restored to its normal resting state, it is ready to fire another _____.

nerve impulse

nerve impulse 1091. Let us say that a _____
is conducted along the neuron and that the neuron is
then restored to its normal resting condition.

neuron 1092. Suppose that a second nerve impulse is then
conducted along the _____.

absolute 1093. Following this second nerve impulse, the neu-
refractory ron must, again, go through the _____
relative refractory _____ period followed by the
_____ period.

normal 1094. When this second relative refractory period is
resting concluded, the neuron is completely recharged and
is, once again, returned to its _____
_____ state.

neuron 1095. You can thus see that this series of events con-
tinues for as many times as a _____ fires.

semi-permeable 1096. We are now in a position to enlarge upon our
definition of a semi-permeable membrane. Recall that
a _____ membrane is a thin
sheet of tissue that has tiny holes in it.

holes 1097. When a nerve impulse is conducted, sodium
ions pass through these tiny _____ to the in-
side of the membrane.

potassium ions 1098. However, in addition to the sodium ions on the
outside, and the _____
on the inside, there are a number of other ions in a
neuron.

small 1099. These various ions are of different size. That
is, some are relatively large whereas others are rela-
tively _____.

semi-permeable 1100. Hence, some ions are too large to get through
membrane the holes in the _____
_____.

1101. That is, although sodium ions may pass through the holes to the inside, the holes are too small for other kinds of _____ to pass through.

1102. Similarly, although the holes are large enough to pass potassium ions to the outside, they are sufficiently small to exclude the passage of other kinds of _____ that are present in a neuron.

1103. If all of the various kinds of ions in a neuron could get through the holes, we would have a completely permeable membrane, rather than just a _____ membrane.

1104. A semi-permeable membrane is one that is large enough to pass some particles, but _____ large enough to allow other particles through.

1105. Let us now consider the speed with which a _____ is conducted along a neuron.

1106. Actually the speed of a nerve impulse varies with the size of the _____ that is conducting it.

1107. In large neurons, the nerve impulse may travel as fast as 120 meters per second. But, in _____ neurons, it moves as slowly as one meter per second.

1108. A nerve impulse travels faster in a _____ neuron than it does in a _____ neuron.

1109. The greater the diameter of the neuron, the _____ the speed of the nerve impulse.

1110. Or put the other way: the smaller the diameter of the neuron, the _____ the speed of the nerve impulse.

1111. Nerve impulses may travel as fast as 120 meters per second in _____ neurons.

1112. Nerve impulses, however, go as slowly as one meter per second, in _____ neurons.

1113. The speed of a nerve impulse varies between approximately one meter per second and _____ meters per second.

1114. The greater the diameter of the neuron, the _____ the speed of the nerve impulse.

1115. Consider, now, a nerve impulse that has been conducted through the cell body and arrives at the end of the neuron called the _____.

1116. What happens to the nerve impulse once it reaches the _____ end of the neuron?

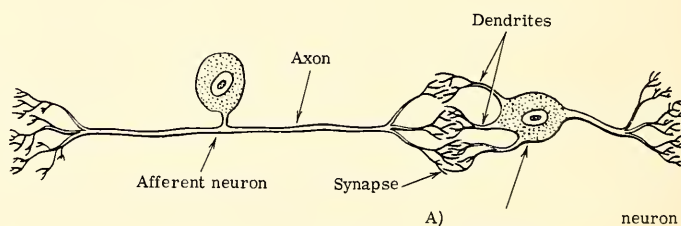


FIGURE 55

1117. In Figure 55, we see two neurons. The first is an afferent neuron. In the blank provided, write in the name of the second type of neuron.

1118. A typical arrangement of neurons is shown in Figure 55. Note that the first neuron makes junction with the second neuron, but that the two _____ do not actually touch each other.

1119. Observe, in Figure 55, that the axon of the first neuron does not touch the _____ of the second neuron.

1120. Rather, there is a small space between the two _____ called a synapse (sĭnăps').

1121. The small space between two neurons is called a _____.

1122. How does the nerve impulse cross the _____ in order to get from one neuron to the next?

1123. Recall that there are both chemical and _____ aspects of a nerve impulse.

1124. Therefore, we can expect both chemical and electrical events to occur at the synapse between two neurons, in order for the _____ to cross from the first neuron to the second.

1125. For instance, you have probably seen a spark of electricity jump a gap between two conductors. In like manner, the electrical components of a nerve impulse can “jump” across the _____ between two neurons.

1126. Because there are electrical aspects of a nerve impulse, when a nerve impulse reaches the axon end of a neuron, it can “spark,” or jump, across the _____ so that the nerve impulse is transmitted to the next _____.

1127. A nerve impulse may cross a synapse because the _____ that is generated may spark, or jump, across to the next neuron.

1128. In addition to the electrical events, chemical events also occur when a _____ comes to the end of an axon.

1129. When the nerve impulse comes to the axon end, certain chemicals are released from the neuron. These chemicals then “float” across the _____ to cause a chemical reaction in the second neuron.

chemical 1130. The release of certain chemicals by the firing neuron produces a _____ reaction in the neighboring neuron.

*synapse
reaction* 1131. Chemicals released by one neuron cross a _____ and may set off a chemical _____ in the second neuron.

nerve impulse 1132. The resulting chemical reaction, in the second neuron, may then cause that second neuron to fire a _____.

cell body 1133. A second neuron may receive a nerve impulse at one of two places: at its dendrites, or at its _____.

*axon
cell body* 1134. Therefore, synapses occur between the axon of one neuron and the dendrites of a second, and also between the _____ of one neuron and the _____ of a second.

*absolute
threshold* 1135. Recall that a stimulus from an organism's environment must be above the _____ before it can excite a receptor.

stimulus 1136. The stimulus from a person's external environment may be thought of as an external _____.

stimulus 1137. In like manner, we may think of a nerve impulse as an internal _____.

synapse 1138. We know that nerve impulses, like external stimuli, differ in intensity. A very intense nerve impulse will release a large amount of electricity to cross a _____ to a second neuron.

small 1139. A weak nerve impulse, however, will only produce a _____ amount of electricity to cross a synapse.

1140. Similarly, an intense nerve impulse will liberate more chemicals to cross a synapse than will a _____ nerve impulse.

weak

1141. The stronger a nerve impulse, the greater the amount of _____ generated, and the greater the amount of _____ liberated.

*electricity
chemicals*

1142. If the intensity of a nerve impulse is above the _____, then that nerve impulse will cross the synapse to fire, or excite, the neighboring neuron.

absolute threshold

1143. If the nerve impulse is below the _____, however, it will not cross the _____ to excite the next neuron.

*absolute threshold
synapse*

1144. If a nerve impulse is above the absolute threshold, then it will cross the _____ and be conducted along the dendrites, or through the _____, of the neighboring neuron.

*synapse
cell
body*

1145. If the cell body receives a nerve impulse, that impulse is conducted through the cell body and along the _____ of the neuron.

axon

1146. If the nerve impulse is below the absolute threshold, however, the cell body will _____ receive the nerve impulse.

not

1147. In this event, the _____ simply dies at the synapse.

nerve impulse

1148. The cell body and the axon of a neuron have a specific amount of ENERGY that can be released when the _____ conducts a nerve impulse.

neuron

energy 1149. If, in fact, a nerve impulse is conducted through the cell body and axon, all of the _____ of these parts of the neuron is released.

none 1150. If the cell body, on the other hand, does not successfully receive the nerve impulse, then _____ of this energy is released.

all
none 1151. This is known as the ALL OR NONE LAW OF NEURAL CONDUCTION. That is, either the cell body and axon will release _____ of their energy, or they will release _____ of their energy.

All; None 1152. The _____ or _____ Law of Neural Conduction applies to the cell body and axon of a neuron.

cell body
axon
energy 1153. The All or None Law of Neural Conduction states that the _____ and the _____ of a neuron will release all of their _____ or they will not release any of it.

energy 1154. If a nerve impulse goes through the cell body and axon, these parts will release all of their _____.

Neural Conduction 1155. This is known as the All or None Law of _____.

Law
dendrites 1156. Whereas the All or None _____ of Neural Conduction applies to the axon and cell body, it does not apply to the _____.

synapse
energy 1157. That is, if a nerve impulse crosses a _____ to excite a dendrite, the dendrite may release less than all of its _____.

axon 1158. If the dendrite releases all of its energy, then the nerve impulse is conducted right along until it ends up at the _____ end of the neuron.

cell body 1159. If the dendrite, however, releases only a small amount of its energy, then the nerve impulse may die before it reaches the _____ and the axon.

smaller 1160. If a dendrite receives a nerve impulse, it is possible for that nerve impulse to get smaller and _____ as it moves along.

dendrite 1161. If the nerve impulse continues to get smaller as it moves along a _____ of a neuron, it may die.

synapse
dendrite 1162. We can thus see that a nerve impulse may die in either of two places: 1) before it gets to the next neuron at the _____ between two neurons, and 2) at a _____ (part) of a neuron.

nerve impulse 1163. The cell body and the axon act as a unit. If one part receives a _____, then so does the other part.

All
None
dendrites 1164. The cell body and axon obey the _____ or _____ Law of Neural Conduction, but the _____ do not.

axon 1165. If the cell body receives a nerve impulse, then it and the _____ will expend, or fire, all their energy.

All; None
Law; Neural
Conduction 1166. This is known as the _____ or _____ of _____.

1167. This completes our discussion of the neuron and the nerve impulse. Let us now summarize what we have said.

✓
nerve impulse 1168. If a stimulus impinges on one of an organism's receptors, it may excite that receptor. In this event, a _____ is generated.

1169. The nerve impulse is then received by an
afferent _____ neuron.

1170. The afferent neuron, like all neurons, may re-
dendrite ceive the nerve impulse at its _____
cell body or at its _____.

1171. In the afferent neuron, the _____
dendrite and the _____ are both rather long.
axon

(either order)

1172. The afferent neuron has but one axon and one
dendrite _____.

1173. In the afferent neuron, the _____
cell projects up from the dendrite and axon.
body

1174. Once an afferent neuron receives a nerve im-
spinal pulse from a receptor, the nerve impulse is then con-
ducted into the _____ cord.

1175. When the nerve impulse gets to the axon end
association of the afferent neuron, it may cross the synapse and
excite an _____ neuron.

1176. The association neuron would only receive the
absolute threshold impulse if the intensity of the impulse is above the
_____.

1177. If the intensity of the impulse is below the
synapse absolute threshold, it would die at the _____
between the two neurons.

1178. Assume that the association neuron success-
cell body fully receives the nerve impulse, at either its dendrites,
or at its _____.

1179. In this event, the nerve impulse would be
axon conducted through the association neuron until it
comes to the end of the neuron called the _____.

1180. The nerve impulse may then cross the synapse and thus be transmitted out of the spinal cord along an _____ neuron.

1181. Once an efferent neuron receives a nerve impulse, it transmits the nerve impulse to an _____.

1182. This process of an afferent neural impulse running through the spinal cord and out along an efferent neuron is known as a _____.

1183. Once a nerve impulse gets inside the spinal cord, however, it not only can go out to an effector, but it can also go up the spinal cord to the _____.

1184. In its normal resting state, there are atoms with _____ charges of electricity on the outside of the semi-permeable membrane, and _____ charged ions on the inside.

1185. When a neuron conducts a nerve impulse, the positive ions move to the inside of the _____.

1186. During the passage of a nerve impulse, two types of events occur. These are _____ and _____ aspects of the nerve impulse.

1187. The chemical events that occur during the passage of a nerve impulse involve the passage of _____ ions from the outside to the inside of the semi-permeable membrane, and of _____ ions from the inside to the outside.

1188. As a nerve impulse passes a given point on a neuron, there is: first, a small amount of electricity generated, followed by a very large amount called a _____.

- small* 1189. After the spike potential, another _____ amount of electricity is given off.
- absolute* 1190. Two periods follow the passage of a nerve
refractory impulse. The first is the _____
relative refractory _____ period, and the second is the
 _____ period.
- recharges* 1191. It is during these two periods that the neuron
 _____ itself.
- outside* 1192. While a neuron is recharging itself, the sodium
 ions return to the _____ of the semi-permeable membrane.
- absolute* 1193. A neuron cannot receive a new impulse when it
 is in the _____ refractory period.
- relative* 1194. It can, however, successfully receive a new
refractory nerve impulse when it is in the _____
 _____ period, provided that the intensity of the new impulse is very high.
- cell* 1195. The All or None Law applies to the _____
body; axon _____ and the _____ parts of a neuron, but
dendrite it does not apply to the _____ part.
- all; none* 1196. The All or None Law of Neural Conduction
 states that the cell body and axon will give off either
 _____ or _____ of their energy.
- faster/greater* 1197. The greater the diameter of a neuron, the
 _____ the speed of a nerve impulse that is conducted along it.
- synapse* 1198. The space between two neurons is called a
 _____.

THE NERVOUS SYSTEMS

Section XI: The Central Nervous System—The Spinal Cord

neurons 1199. We have said that a nerve is a collection of _____.

neurons 1200. The spinal cord is a much more complex structure than a nerve. Like a nerve, the spinal cord consists of an extremely large number of _____.

neurons 1201. The brain, too, like a nerve and the spinal cord, is also made up of an extremely large number of _____.

spinal cord 1202. A very complex system of neurons make up the brain and _____.

system 1203. The brain and spinal cord work very closely together. It is for this reason that they form a single system called the central nervous _____.

nervous 1204. There are two major divisions of the central _____ system.

central nervous 1205. The two divisions of the _____ system are the brain and spinal cord.

central nervous system 1206. The brain and spinal cord make up the _____.

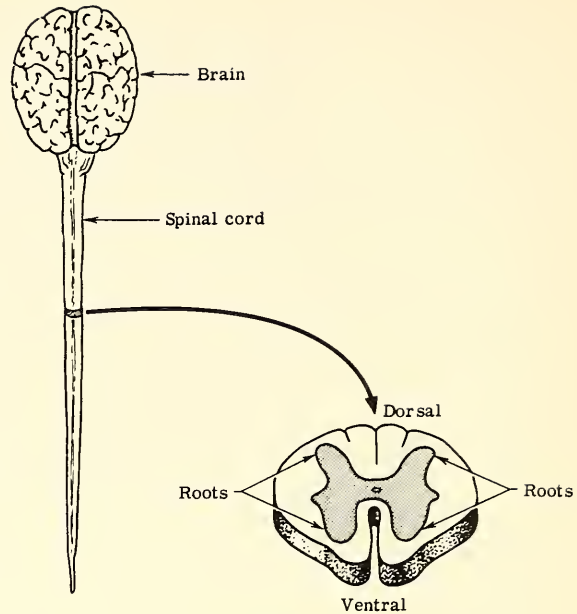


FIGURE 56

brain
spinal cord

1207. In the upper part of Figure 56, we see a diagram of the two parts of the human central nervous system. These two parts are the _____ and the _____.

spinal cord

1208. If the spinal cord were severed, and bent forward toward you, you would see a cross section of it, such as shown in the bottom part of Figure 56. Note the gray matter, in the shape of a butterfly, on the inner part of the _____.

gray

1209. The spinal cord consists of gray matter and white matter. The cross section shows both the white and the _____ matter of the spinal cord.

white matter

1210. The gray matter, in the shape of a butterfly, is on the inside, and the _____ is on the outer parts of the spinal cord.

white
gray

1211. On the inside of the spinal cord one finds _____ matter, whereas in the outer parts one finds _____ matter.

cell bodies 1212. Recall the three parts of a neuron. The axons and dendrites are usually white, whereas the _____ of neurons are gray.

white 1213. Cell bodies of neurons are gray, whereas the axons and dendrites are usually _____ in color.

cell bodies 1214. Because the inner part of the spinal cord is gray, we know that it could not contain many axons and dendrites. Rather, this butterfly-shaped area primarily contains _____ of neurons.

white 1215. The outer part of the spinal cord is _____ in color.

*axons
dendrites
(either order)* 1216. The outer part of the spinal cord does not consist of cell bodies, but consists mainly of _____ and _____.

*gray
white* 1217. With regard to color, in general, cell bodies make up the _____ matter of the spinal cord, whereas axons and dendrites make up its _____ matter.

ventral 1218. In Figure 56, we have indicated that the back part of the spinal cord is the DORSAL part, whereas the front is the _____ part.

dorsal 1219. Thus, the ventral part of the spinal cord is toward your stomach, whereas the _____ part is toward your back.

roots/horns 1220. Note, also, that the gray matter of the spinal cord has four projections called roots, or horns. Study the shape of these four projections called _____.

dorsal roots 1221. The two roots that project toward the front of the body are called the ventral roots, whereas the two roots that project toward the dorsal (back of the body) are called _____.

1222. The gray matter of the spinal cord consists primarily of the parts of neurons called and has four roots: the two that project toward the back of the spinal cord are called the , whereas the two that project toward the front of the spinal cord are called .

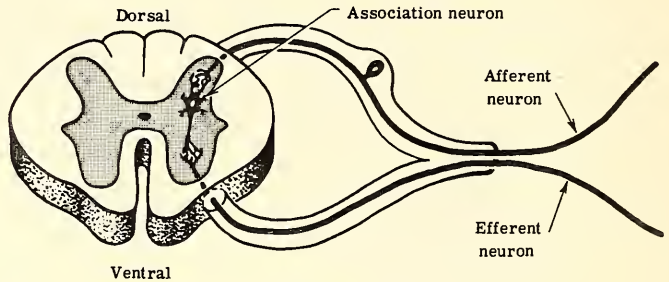


FIGURE 57

1223. In Figure 57, we show a simple reflex arc. Here, an afferent neuron connects with an , which in turn connects with an .

1224. Note that the association neuron is contained within the matter of the spinal cord.

1225. Recalling that the gray matter is made up primarily of cell bodies, we may note that it contains the of the efferent neuron.

1226. On the basis of Figure 57, we can state a famous law known as the Bell-Magendie .

1227. The first part of the Bell-Magendie Law states that the afferent neurons enter the spinal cord through the roots that we have called the . Study this in Figure 57.

1228. The dorsal roots of the spinal cord receive neural impulses.

- Bell* 1229. The _____-Magendie Law has two parts.
- Magendie* 1230. The first part: The Bell-_____ afferent Law states that _____ neurons enter the dorsal roots of the spinal cord.
- Bell-Magendie* 1231. Afferent neural impulses enter the dorsal roots of the spinal cord, according to the _____-_____ Law.
- ventral* 1232. These impulses are then conducted through the association neuron to the efferent neuron, then leave the spinal cord by means of the _____ roots.
- ventral* 1233. Hence, the second part of the Bell-Magendie Law states that efferent neural impulses leave the spinal cord by means of the _____ roots.
- efferent* 1234. The ventral roots conduct _____ neural impulses out of the spinal cord.
- Magendie* 1235. This is the second part of the Bell-_____ Law.
- efferent* 1236. Because efferent neurons exit from the spinal cord by means of the ventral roots, as shown in Figure 57, _____ neural impulses are conducted out of the spinal cord through the _____ roots.
- Bell-Magendie* ✓ 1237. Both parts of the _____-_____ Law stated together are that _____ neural impulses enter the spinal cord through the _____ roots, and efferent neural impulses leave the spinal cord through the _____ roots.
- dorsal*
- ventral*
- Bell-Magendie* 1238. The Englishman, Sir Charles Bell, and the Frenchman, François Magendie, working independently, made the discovery that we, today, call the _____-_____ Law.

afferent 1239. If the dorsal roots of the spinal cord were destroyed, then one could not receive _____ neural impulses.

environment 1240. In this event, a person's spinal cord and brain could not receive sensory information (stimuli) from his _____ for the part of the body affected.

dorsal 1241. A person who could not feel pain in a certain part of his body, for instance, might have a lesion (lē'zhən—a destruction) in his _____ roots.

ventral roots 1242. In like manner, a lesion in the VENTRAL roots would not allow one to make a response for the region affected. With polio, for instance, a person is paralyzed because the nerve cells in his _____ are destroyed.

neurons 1243. We know that nerves contain neurons. Hence, afferent nerves are made up of afferent _____.

afferent dorsal 1244. Afferent nerves that contain _____ neurons enter the spinal cord by means of the _____ roots.

efferent ventral 1245. Efferent nerves contain _____ neurons that leave the spinal cord through the _____ roots.

efferent; spinal 1246. There are a large number of afferent nerves that enter the spinal cord, and a large number of _____ nerves that leave the _____ cord.

spinal nerves 1247. SPINAL NERVES is the name given to these afferent and efferent nerves. All nerves that enter or leave the spinal cord are called _____.

afferent 1248. Afferent neural impulses enter the dorsal roots of the spinal cord by means of _____ neurons.

1249. These afferent neurons are contained within afferent nerves. The afferent and efferent nerves are called _____ nerves.

1250. Spinal nerves go into and out of the _____.

1251. The function of spinal nerves is to deliver _____ neural impulses into the spinal cord and to conduct _____ neural impulses out of the spinal cord.

1252. Let us now see how nerve impulses, once they get into the spinal cord, move up the spinal cord to the _____.

1253. We will also study how nerve impulses leave the brain and move down the _____.

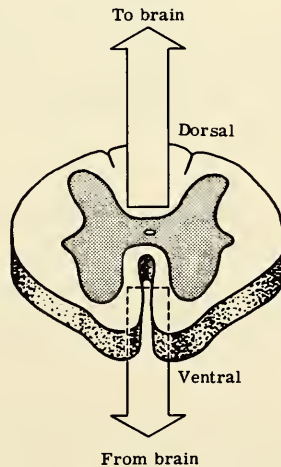


FIGURE 58

1254. In Figure 58, note that the ventral and the _____ parts of the spinal cord are labeled.

1255. As you can see in Figure 58, nerve impulses are typically conducted up to the brain in the _____ part of the spinal cord.

1256. Also note, in Figure 58, that impulses typically are conducted down from the brain along the _____ part of the spinal cord.

ventral

1257. In general, nerve impulses are conducted to the brain along the _____ part of the spinal cord, and FROM the brain in the _____ part of the spinal cord.

dorsal

ventral

1258. Recall that the white matter of the spinal cord contains dendrites and _____.

axons

1259. Many of these axons and dendrites run up and down the _____.

spinal cord

1260. Nerve impulses are conducted up to the brain and down from the brain by means of these dendrites and axons that make up the _____ matter of the spinal cord.

white

1261. Afferent neural impulses that enter through the _____ roots of the spinal cord are conducted to the brain along the axons and dendrites that are in the back, or _____ section, of the spinal cord.

dorsal

dorsal

1262. Nerve impulses that enter the spinal cord run to the _____ along neurons contained in the _____ section of the spinal cord.

brain

dorsal

1263. Once nerve impulses leave the brain, they are conducted down the spinal cord along neurons that make up its _____ part.

ventral

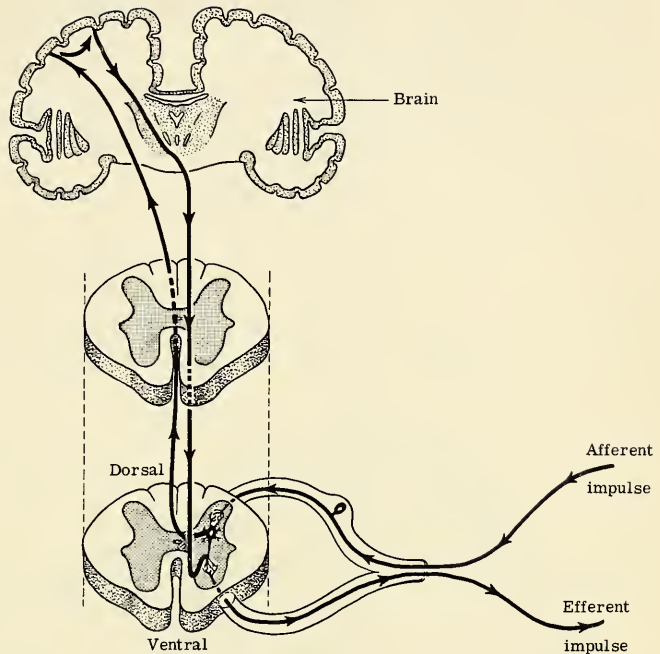


FIGURE 59

1264. This process is represented in Figure 59. Note how an afferent neural impulse is conducted into the spinal cord by means of an _____ neuron.

1265. The impulse then enters the spinal cord through the _____ root.

1266. It is then conducted up to the brain, in the _____ section of the spinal cord.

1267. Once the nerve impulse enters the brain, it sets off a complex of activity. Eventually an impulse descends from the brain and is transmitted along the _____ section of the spinal cord.

1268. The impulse then leaves the spinal cord, through the _____ roots, and is conducted to an effector by means of an _____ neuron.

THE NERVOUS SYSTEMS

Section XII: The Central Nervous System—The Brain

brain 1269. Let us now consider, in greater detail, the complex activity that occurs when a nerve impulse ascends the spinal cord and enters the _____.

neurons 1270. We saw that the spinal cord is made up of a large number of neurons. Though it is much more complex in structure, the brain is also made up of a large number of _____.

central nervous 1271. The brain and spinal cord, taken together, make up the central nervous system. Although we shall later consider other nervous systems, for now we are studying the _____ system.

central nervous system 1272. We have already studied the spinal cord, now we will turn to the other part of the _____, that is, we will now study the _____.

brain

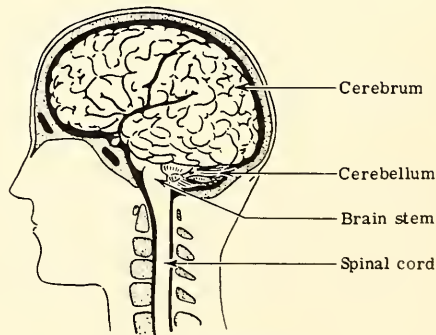


FIGURE 60

brain 1273. In Figure 60, we see a diagram of the upper part of the spinal cord and of several parts of the human brain. Note that as it extends to the brain, the spinal cord runs into the _____ stem.

1274. The other two parts of the brain indicated are the *cerebrum* (sĕr'ə brəm) and the *cerebellum* (sĕr'ə bĕl'əm). The cerebrum constitutes the major part of the brain, whereas the relatively smaller _____ projects below it.

cerebellum

1275. Two major parts of the brain are the cerebrum and the cerebellum. The _____ is larger than the _____.

cerebrum
cerebellum

1276. The larger _____ is above the smaller _____.

cerebrum
cerebellum

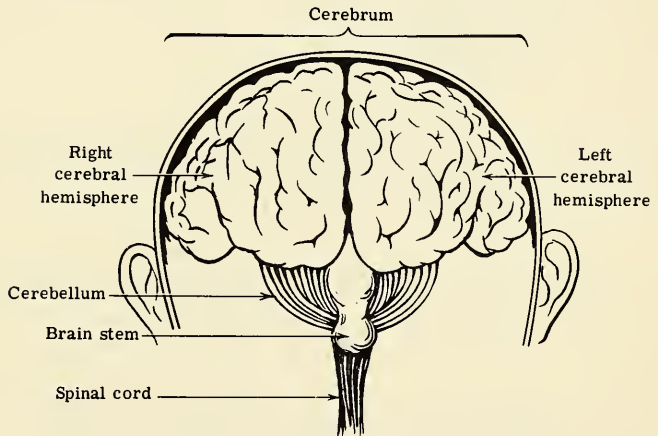


FIGURE 61

1277. In Figure 61, we see a front view of the brain. Most prominent, because it is the largest part of the brain, is the _____.

cerebrum

1278. Note that the cerebrum is divided into two parts: the left CEREBRAL HEMISPHERE and the right _____.

cerebral hemisphere

1279. The cerebrum consists of two _____ hemispheres.

cerebral

1280. Because Figure 61 is a front view of the brain, most of the back part is not shown. For this reason, the structure in the back lower part called the _____ can hardly be seen.

cerebellum

brain 1281. The spinal cord joins the brain at the brain stem. The _____ stem is the lower part of the brain.

brain stem 1282. The spinal cord is joined to the larger part of the brain by means of the _____.

cerebrum 1283. The largest part of the brain is known as the _____.

cerebral hemisphere 1284. There are two major divisions of the cerebrum: the left _____
right cerebral and the _____
hemisphere _____.

cerebellum 1285. In the lower back part of the brain, below the cerebrum, one finds a large structure called the _____.

cerebrum 1286. Two cerebral hemispheres make up the _____.

cerebellum 1287. The large sponge-like structure behind and below the cerebrum is the _____.

brain stem 1288. Between the spinal cord and the cerebrum one finds the lower part of the brain called the _____.

1289. If we sliced the brain down the middle between the two cerebral hemispheres and turned it sideways, we would have a side view of half of the brain, as shown in Figure 62. Fill in the blanks indicated by A, B, C, and D.

- A. Cerebrum (Right Cerebral Hemisphere)
- B. Cerebellum
- C. Brain stem
- D. Spinal cord

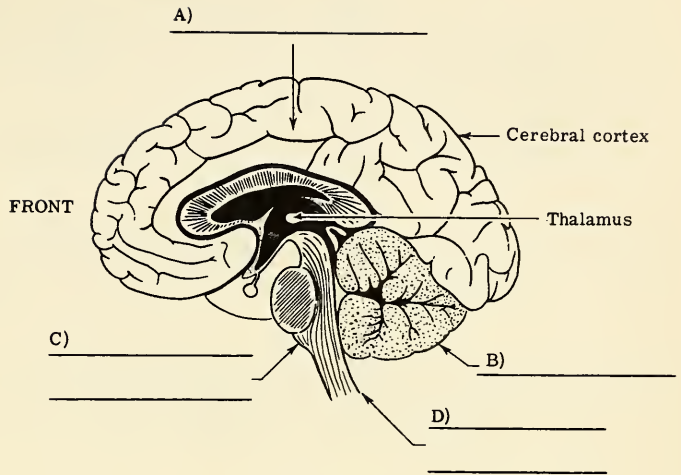


FIGURE 62

1290. Note, in Figure 62, that two other aspects of the brain have been identified—the thalamus and the _____ cerebral _____ cortex.

1291. The thalamus is an internal part of the brain, whereas the cerebral _____ is the outer layer of the cerebrum.

1292. The two new parts of the brain, shown in Figure 62, are the CEREBRAL CORTEX and the THALAMUS. The cerebral cortex is the outer layer of the cerebrum, whereas the _____ is an internal part of the brain.

1293. Note the location of the thalamus. The _____ is directly above the brain stem.

1294. Because of its importance, we shall return to the thalamus later. For now, simply note the close relationship between the brain stem and the _____.

1295. All these parts of the brain are extremely important, but the cerebral _____ is especially important.

1296. This outer layer of the cerebrum is about ONE-FOURTH INCH in thickness, and is called the *cerebral cortex* _____.

one-fourth/¼ 1297. The cerebral cortex is about _____ inch in thickness.

cerebral 1298. Of all the animals, man has the most highly developed _____ cortex.

cell 1299. The cerebral cortex, like the inner butterfly-shaped part of the spinal cord, is composed of the parts of neurons called _____ bodies.

gray 1300. Because it is made up of cell bodies, the cerebral cortex, like the inner part of the spinal cord, is _____ in color.

cell bodies 1301. Dendrites and axons do not make up the inner part of the spinal cord and the cerebral cortex, but rather, these nervous regions are composed of _____.

gray 1302. Hence, both the spinal cord and the cerebral cortex are _____ in color.

gray 1303. For this reason they are both referred to as _____ matter.

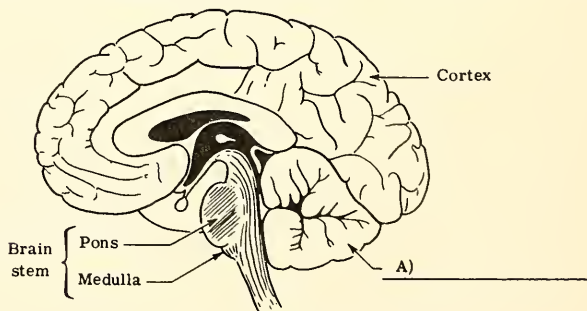


FIGURE 63

1304. Identify the part indicated in Figure 63 by filling in the blank.
A. *cerebellum*

1305. If we sliced through one of the cerebral hemispheres of the cerebrum, we could see the cerebral cortex. Figure 63 shows the cerebral cortex as the outer layer, or bark, of the major part of the brain called the _____.

1306. The outer layer of each cerebral hemisphere is called the cerebral _____ and is approximately _____ of an inch thick.

1307. Also note, in Figure 63, that the pons and the medulla are identified as the two major parts of the _____.

1308. As it enters the brain, the _____ joins the brain stem.

1309. The brain stem consists of two parts: 1) the medulla, and 2) the _____.

1310. The lower part of the brain is called the _____, and consists of two parts: the _____ and the _____.

1311. As you can see in Figure 63, the part of the brain stem that is closest to the cerebrum is the _____.

1312. The part of the brain stem that is closest to the spinal cord is the _____.

1313. In the brain stem, the _____ is above the _____.

1314. As nerve impulses ascend the spinal cord and enter the brain stem, they first go through the part of the brain stem called the _____; after which they go through the higher part of the brain stem called the _____.

1315. Man has a large and very highly developed cerebral cortex. It is so large, in fact, that it must fold over in order to fit into the skull, or CRANIUM (krā'-nīəm). If the cortex did not fold over, it could not fit into man's _____.

cranium/skull

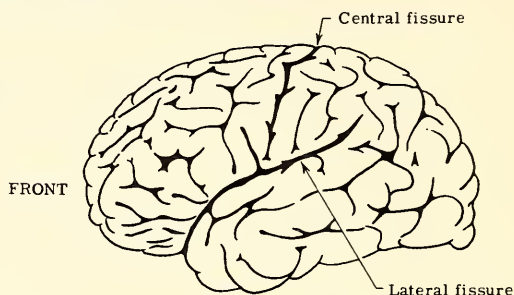


FIGURE 64

1316. In Figure 64, we show a side view of the cerebrum. The wavy lines indicate folds of the cerebral _____ that allow it to fit into the _____.

cortex; cranium

1317. If you took a piece of cloth and rumbled it up, it would have many ridges and valleys. The ridges and valleys would look similar to the folds of the cerebral _____ shown in Figure 64.

cortex

1318. These folds, or ridges and valleys, are called CONVOLUTIONS. The _____ cortex has a very large number of convolutions.

cerebral

1319. The wavy lines, in Figure 64, represent the _____ of the brain.

convolutions

1320. Note, in Figure 64, how the numerous folds, called _____, run throughout the entire cerebral cortex.

convolutions

1321. Figure 64 also shows two of the major identifying features of the cortex. One is a vertical groove, or FISSURE (fish'ər) called the central _____.

fissure

1322. The central fissure is so called because it is in the central part of the cerebrum. Approximately half of the cerebrum is in front of the _____.

central fissure

1323. The fissure that is in the central part of the brain, and that runs in an up-and-down (vertical) direction, is called the _____.

central fissure

1324. As Figure 64 shows, the second major identifying mark of the cortex is the lateral _____.

fissure

1325. The lateral fissure runs in a lateral, or sidewise, fashion. Note, in Figure 64, that the _____ is directly below the central fissure.

lateral

fissure

1326. The two major fissures of the cortex are the _____ and the _____.

central fissure

lateral fissure

(either order)

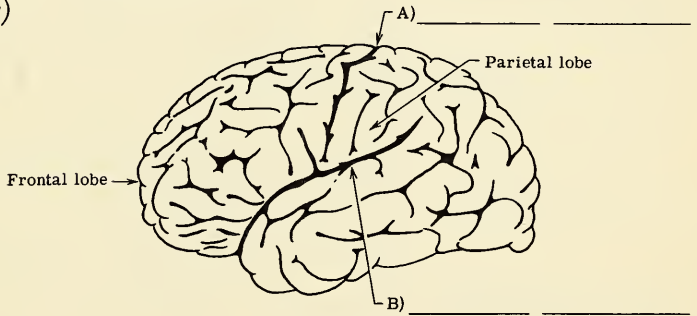


FIGURE 65

1327. In Figure 65, we see the left cerebral hemisphere. Write the names of the two major fissures in the blanks provided.

A. central fissure

B. lateral fissure

1328. The lateral and central fissures help to mark off the **FOUR** major regions of each cerebral hemisphere. These _____ major regions are called **LOBES**.

four

1329. Note, in Figure 65, that the **FRONTAL LOBE** is in front of the central fissure, whereas the **PARIETAL** (pə rī'ə təl) **LOBE** is behind, or in _____ of, the _____ fissure.

back

central

1330. The lobe in front of the central fissure is the _____.

frontal lobe

1331. In back of the central fissure we find the
parietal lobe _____.

cerebral hemispheres 1332. The cerebrum consists of two _____.

right cerebral hemisphere 1333. The left cerebral hemisphere is approximately a mirror image of the _____.

central lateral (either order) 1334. Each cerebral hemisphere is marked off by two major fissures called the _____ fissure and the _____ fissure.

lobes 1335. Each cerebral hemisphere also has four major regions called _____.

frontal 1336. The lobe in the front part of each cerebral hemisphere is called the _____ lobe.

central 1337. The frontal lobe is located in front of the _____ fissure.

parietal 1338. In both the left and right cerebral hemispheres, the _____ lobe is directly behind the central fissure.

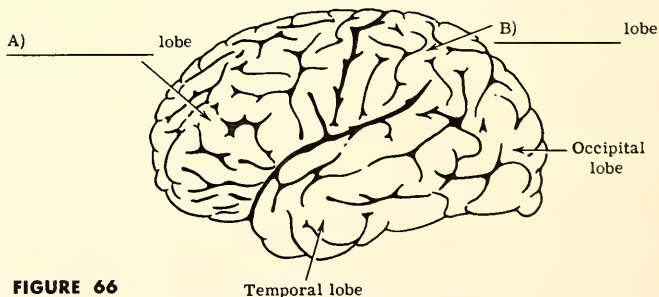


FIGURE 66

Temporal lobe

1339. In Figure 66, write the names of the two lobes indicated by the blanks.

A. frontal lobe
B. parietal lobe

1340. Also note that the *occipital* (ök šip'ətəl) LOBE is at the very _____ of each cerebral hemisphere.
- back/rear*
1341. The name of the lobe at the rear, or very back, of each cerebral hemisphere is the _____.
- occipital lobe*
1342. As you can see in Figure 66, the TEMPORAL lobe is below the lateral fissure and in front of the _____ lobe.
- occipital*
1343. There are two lobes immediately before, or in front of, the occipital lobe. In fact, these two lobes actually connect to the occipital lobe. These are the parietal lobe and the _____.
- temporal lobe*
1344. Each cerebral hemisphere contains _____ lobes.
- four*
1345. Immediately in front of the central fissure, one finds the _____.
- frontal lobe*
1346. Immediately in back of the central fissure is the _____.
- parietal lobe*
1347. At the very back of each cerebral hemisphere one finds the _____.
- occipital lobe*
1348. Below the lateral fissure is the _____.
- temporal lobe*
1349. The temporal lobe is found below the _____ fissure.
- lateral*
1350. The parietal lobe is found immediately behind the _____ fissure.
- central*
1351. The _____ lobe is found immediately in front of the _____ fissure.
- frontal central*

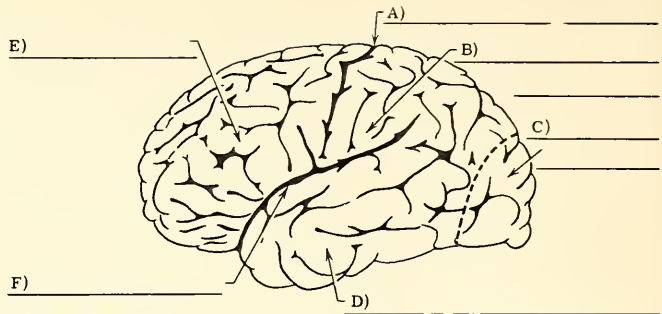


FIGURE 67

1352. In Figure 67, write in the names of the two major fissures and the four lobes of each cerebral hemisphere. If you made any mistakes, you should go back to Frame 1321 and read through the program to this point again.

- A. Central fissure
- B. Parietal lobe
- C. Occipital lobe
- D. Temporal lobe
- E. Frontal lobe
- F. Lateral fissure

1353. Without looking at the preceding discussion, draw a diagram of the left cerebral hemisphere and label the two major fissures and the four lobes. Then check yourself.

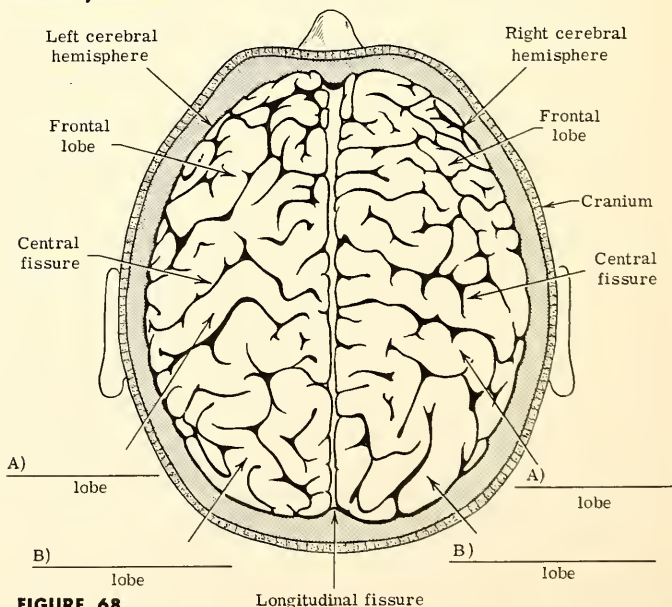


FIGURE 68

cerebral
hemispheres

1354. In Figure 68, we see a top view of the two _____ that compose the cerebrum.

central

1355. Note that the frontal lobe of each cerebral hemisphere is in front of each _____ fissure.

A. parietal; parietal
B. occipital;
occipital

1356. Fill in the names of the lobes, in the blanks provided in Figure 68, for each cerebral hemisphere.

longitudinal
fissure

1357. Note the LONGITUDINAL FISSURE, in Figure 68. The fissure that divides the cerebrum into two cerebral hemispheres is called the _____.

longitudinal
fissure

1358. The right cerebral hemisphere is separated from the left cerebral hemisphere by means of the _____.

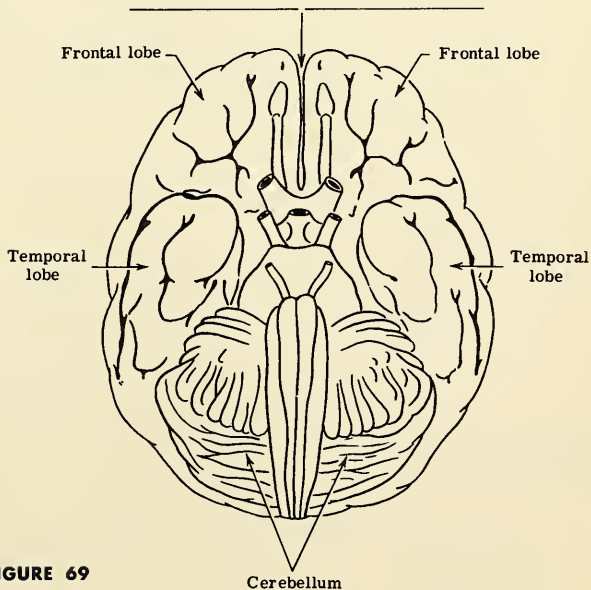


FIGURE 69

1359. Figure 69 shows a bottom view of the brain. Write in the name of the fissure in the blanks provided.

Longitudinal
Fissure

*right cerebral
hemisphere;
longitudinal
fissure*

1360. Observe how the left cerebral hemisphere is separated from the _____ by means of the _____.

*frontal lobes;
temporal lobes
(either order)*

1361. In this bottom view of the brain, the only lobes that you can see are the _____ and the _____ of both cerebral hemispheres.

*parietal
occipital
(either order)*

1362. Observe that you cannot see the _____ lobes and the _____ lobes.

cerebellum

1363. You could have seen the bottom of the occipital lobes, in Figure 69, had we not hidden them by showing you the _____.

1364. Let us now review the parts of the brain.

brain stem

✓ 1365. The spinal cord joins the brain at its lower part. This lower part of the brain that connects with the spinal cord is called the _____.

*pons; medulla
(either order)*

1366. There are two major parts of the brain stem: the _____, and the _____.

*pons
medulla*

1367. In the brain stem, the _____ is higher than, or above, the _____.

longitudinal fissure

1368. The cerebrum is the largest part of the brain. It is divided into two cerebral hemispheres by the _____.

cerebellum

1369. The large sponge-like structure at the lower rear of the cerebrum is called the _____.

four

1370. The cerebral cortex in each cerebrum is divided into _____ lobes.

frontal 1371. The lobe nearest the forehead and in front of the central fissure is the _____ lobe.

parietal 1372. Immediately behind the central fissure one finds the _____ lobe.

occipital 1373. Located at the very rear of each cerebral hemisphere is the _____ lobe.

lateral
temporal 1374. The lobe in front of the occipital lobe, below the parietal lobe, and directly below the _____ fissure, is called the _____ lobe.

1375. Without looking at the preceding discussion, draw a diagram of the left cerebral hemisphere, the cerebellum, the brain stem, and the spinal cord. Identify the two major fissures that appear in this view of the brain; label each of the four lobes, and show the approximate location of the thalamus. Then go back and check yourself.

THE NERVOUS SYSTEMS

Section XIII: Neural Activity and the Central Nervous System

afferent 1376. Let us now follow the path of a nerve impulse and focus particularly on what happens to it when it enters the brain. When a receptor is activated, it generates an _____ neural impulse.

spinal 1377. The afferent neural impulse is then conducted within an afferent (spinal) nerve into the _____ cord.

dorsal 1378. The afferent neural impulse enters the spinal cord by means of its _____ root.

dorsal 1379. It then, typically, moves up the spinal cord along its back, or _____ section.

receptors 1380. As we previously saw, the numerous afferent nerves that enter the dorsal root of the spinal cord are constantly conducting impulses that were generated by _____ distributed throughout the body.

*afferent
neural impulse* 1381. Afferent neural impulses that enter the spinal cord by means of spinal nerves come from various places in the body of the organism. For instance, if someone pinched your foot, an _____
_____ would be conducted from the foot into the spinal cord.

1382. Not all afferent neural impulses from the body enter the spinal cord; certain others go directly to the brain. All afferent nerves which do not enter the spinal cord go directly to the _____.

1383. The OPTIC nerve originates in the eye. The _____ nerve is an example of a nerve that does not enter the spinal cord.

1384. Rather, the _____ nerve goes directly to the brain.

1385. An afferent neural impulse from the eye does not go to the _____, but rather, it directly enters the brain.

1386. We previously mentioned CRANIAL (krā'nīəl) NERVES. _____ nerves go directly to the brain.

1387. Instead of entering the spinal cord, _____ nerves go directly to the brain.

1388. The optic nerve is one of the twelve cranial nerves that directly enter the brain, thus bypassing the _____.

1389. Because they are contained within the cranium, these nerves, which go directly to the brain, are called _____ nerves.

1390. The auditory nerve, which carries nerve impulses from the ear, is another of the twelve _____ nerves that directly enter the brain.

1391. The olfactory nerve carries afferent neural impulses generated by the _____ receptors.

1392. The olfactory nerve is another of the twelve _____ cranial nerves.

1393. The brain stem is the lower part of the
brain; spinal _____ that extends down into the _____
cord _____.

1394. We previously saw that all nerve impulses
brain stem that ascend the spinal cord enter the lower part of the
 brain called the _____.

1395. We have also seen that all afferent neural im-
cranial pulses that come from _____ nerves directly
 enter the brain.

1396. Most of the cranial nerves enter the lower part
brain of the brain called the _____ stem.

1397. We can thus see that most of the afferent
cranial neural impulses, whether they come from spinal nerves
brain stem and ascend the spinal cord, or whether they come
 from _____ nerves, enter the lower part of
 the brain called the _____.

1398. Every afferent neural impulse that enters the
spinal spinal cord crosses over to the opposite side of the
 _____ cord.

1399. Once a nerve impulse crosses to the opposite
cerebral side of the spinal cord, it eventually enters the
 _____ hemisphere on that side of the
 body.

1400. For example, if a nerve impulse enters the
cerebral hemisphere spinal cord from the left side of the body, it crosses to
 the right side of the spinal cord and eventually goes to
 the right side of the cerebrum, or more precisely, to
 the right _____.

1401. An afferent neural impulse from the left side
right of the body will eventually find its way to the
 _____ cerebral hemisphere.

cerebral hemisphere
right

1402. The right cerebral hemisphere receives nerve impulses from the left side of the body, whereas the left _____ receives neural impulses from the _____ side of the body.

right
right; left

1403. Because we shall use this information later, it is important that you remember that nerve impulses from the left side of the body run to the _____ cerebral hemisphere, whereas nerve impulses from the _____ side of the body run to the _____ cerebral hemisphere.

nervous system

1404. An afferent nerve impulse may cross to the opposite side of the spinal cord at the point at which it enters the spinal cord, or it may cross higher up in the central _____.

opposite/other

1405. In some cases, afferent neural impulses go immediately to the OPPOSITE side of the spinal cord. But in other cases, they run up the spinal cord on the side at which they entered and cross over to the _____ side later.

spinal cord

1406. Regardless of where afferent neural impulses enter, they all cross over to the opposite side of the _____ before they reach the cerebrum.

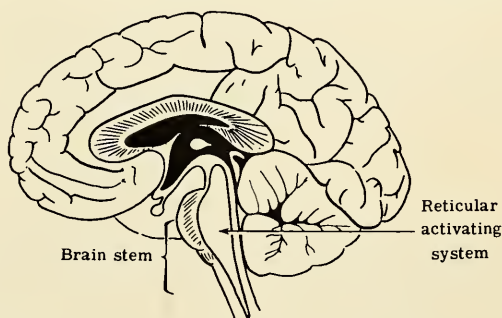


FIGURE 70

activating system

1407. In Figure 70, we see a representation of the RETICULAR ACTIVATING SYSTEM. The reticular _____ is largely in the brain stem, but it also extends down into the spinal cord.

1408. We previously saw that neural impulses that ascend the spinal cord enter the brain at the _____
brain stem _____.

1409. Other afferent neural impulses are conducted directly to the brain stem by means of _____
cranial nerves.

1410. Regardless of whether a nerve impulse came from a cranial nerve or ascended the spinal cord, once it enters the _____ it can go in one of two directions.
brain stem

1411. One direction that a nerve impulse can take is through the brain stem, bypassing the reticular _____ system. (Study the brain stem in Figure 70.)
activating

1412. The second direction that an impulse can take, once it enters the brain stem, is to go through the reticular _____.
activating system

1413. Nerve impulses that enter the brain stem may either go through the _____ activating system, or they may bypass this region.
reticular

1414. Because it activates the cerebral cortex, the important region located primarily in the brain stem is called the reticular _____.
activating system

1415. When afferent neural impulses enter the reticular activating system, a large number of DIFFUSE (spread out in all directions) NEURAL IMPULSES then go to the cerebral _____.
cortex

1416. The reticular activating system activates the cerebral cortex by sending a number of diffuse neural impulses _____ to that structure.

1417. The cerebral cortex is excited, or activated, by the numerous nerve impulses that come from the _____
reticular activating system _____.

1418. When the reticular activating system activates the cortex, the _____ is prepared for the receipt of additional neural impulses _____.

1419. The cerebral cortex is excited, or _____, and thus prepared for the receipt of additional neural impulses, by means of diffuse impulses from the _____
activated reticular activating system _____.

1420. Whereas the reticular activating system sends nerve impulses up to the cortex, the cortex also sends nerve impulses back down into the _____
reticular activating system _____.

1421. When nerve impulses descend from the cerebral _____ to the reticular activating system, activation of the _____
cortex reticular activating system _____ occurs.

1422. We can thus see that there is a kind of "closed loop" between the reticular activating system and the cerebral cortex. That is, the reticular activating system sends neural impulses to activate, excite, or arouse the cerebral cortex, while the cerebral cortex also sends impulses to _____ the reticular activating system.
activate/excite/arouse

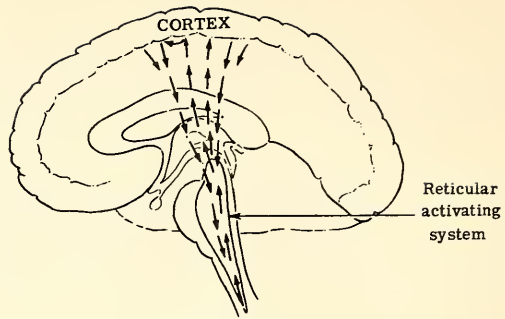


FIGURE 71

1423. In Figure 71, you can see a representation of this process. That is, afferent neural impulses that enter the reticular activating system are transmitted, in a diffuse pattern, up to the _____.

cerebral cortex

1424. As a result of this bombardment of the cortex by incoming impulses from the reticular activating system, the cortex is aroused, or _____.

activated/excited

1425. The cortex, in turn, sends nerve impulses back down into the reticular activating system, whereupon this region also is excited, or _____.

activated/aroused

1426. It is possible to artificially stimulate various parts of the brain by a number of means. For example, small amounts of electricity can be sent into tiny electrodes that are inserted in the cerebral cortex. By electrically stimulating the cerebral cortex (this is not painful), it has been observed that the reticular activating system is excited, or _____.

activated/aroused

1427. When a part of the brain, such as the cortex, is activated, there is an increase in the number of _____ that flow along its neurons.

nerve impulses

1428. Similarly, by electrically stimulating the reticular activating system, an increase in activity of the _____ can be demonstrated.

cerebral cortex

*reticular activating
system; cerebral
cortex*

1429. Such experimental findings as these justify our conclusion that there is a "closed loop" between the _____ and the _____.

activates

1430. The name "reticular ACTIVATING system" is appropriate because it has been demonstrated, in a number of ways, that this system _____ the cerebral cortex.

wake

1431. To consider another example, it was found that if the reticular activating system of a sleeping cat was electrically stimulated, the cat would stop sleeping and awaken, or _____ up.

stimulated

1432. Another finding was that a normally awake cat would become extremely alert when his reticular activating system was electrically _____.

sleep

1433. In another experiment, it was found that if the reticular activating system was isolated by cutting it off from the cerebral cortex, the cat would no longer stay awake, but would go to _____ for a long period of time.

sleeping

1434. It thus seems clear that the reticular activating system is important for the SLEEPING and WAKING states. If the reticular activating system is not active, then the individual seems to be in a _____ state.

waking

1435. But when the reticular activating system is active, the individual seems to be in a _____ state.

not/less

1436. At night, when a person is sleeping, his reticular activating system is _____ active.

active

1437. During the day, when a person is in his normal waking state, however, the reticular activating system is _____.

*afferent
neural impulses*

1438. When a person is asleep, very few external stimuli are exciting his receptors. Hence, during the sleeping state, relatively few _____ are being conducted into the reticular activating system.

*reticular activating
system*

1439. Because very few neural impulses are entering the reticular activating system during sleep, the _____ tends to "shut down."

cerebral cortex

1440. And when the reticular activating system is not active, the _____ is not very active.

sleeping

1441. There is a reduced amount of activity in the cerebral cortex and in the reticular activating system, when a person is in the _____ state.

receptors

1442. When he is awake, however, numerous stimuli impinge on his _____ to set off numerous afferent neural impulses.

waking

1443. Consequently, a large number of afferent neural impulses are entering the reticular activating system during the _____ state.

*medulla; pons
(either order)*

1444. The brain stem is important, not only because it contains the reticular activating system, but because it also contains certain vital nervous centers. We recall that the brain stem has two major structures: 1) the _____, and 2) the _____.

center

1445. The medulla, for instance, has a nervous CENTER that controls BREATHING. Another nervous _____ in the medulla controls the beating of the HEART.

*breathing
heart*

1446. Two important nervous centers in the medulla control _____ and the beating of the _____.

breathe 1447. If you EXTIRPATED (cut out) the nervous center that controls breathing, the person would not be able to _____ properly.

extirpate 1448. Similarly, if one were to cut out, or _____ the nervous center that controlled heart rate, the person's heart would not beat properly.

extirpate 1449. When we perform an operation that destroys, cuts out, or burns out a section of nervous tissue, we say that we _____ that tissue.

extirpate 1450. In order to better understand how the brain functions, physiologists and physiological psychologists frequently perform operations on lower animals. In performing these operations, they frequently destroy, or _____, a certain part of the brain.

brain 1451. It is then possible to observe how the animal behaves with that section of his _____ missing, or extirpated.

extirpated 1452. By thus comparing an animal's behavior before and after a given part of the brain has been _____, knowledge about the function of that part can be obtained.

center 1453. There are intricate neural pathways between the heart and the nervous _____ in the medulla that controls heart rate.

medulla 1454. Hence, nerve impulses are constantly going between the heart and the nervous center in the _____ that controls heart rate.

nerve impulses 1455. You can thus see that the extirpation of a center, such as those for heart rate or breathing, will interrupt the normal flow of _____ that regulate such bodily activities.

center 1456. It was by the tedious process of extirpating small sections of the medulla that scientists discovered the existence of the nervous _____ that controls heart rate.

kinesthetic 1457. Another important function of the brain stem is to receive nerve impulses from the kinesthetic receptors in muscles. Recall that when a muscle contracts, it stimulates the _____ receptors embedded in it.

muscle 1458. The kinesthetic receptors embedded in muscles are called _____ spindles.

spindles 1459. When muscle _____ in the muscles are activated, they send nerve impulses up the spinal cord to the _____ stem.

brain 1460. The brain _____, in turn, sends nerve impulses back down the spinal cord to the effectors, or, more specifically, to the _____.

stem 1461. In the functioning of the KINESTHETIC sense, nerve impulses are conducted to the brain stem, and the brain stem sends impulses back to the muscles. In this way, a continual exchange of nerve impulses occurs between the _____ and the _____.

muscles; brain stem

kinesthetic 1462. We previously saw that integrated behavior is made possible by the _____ sense.

integrated 1463. It is the rapid and frequent interchange between the muscles and the brain stem that contributes to some of our well-coordinated, _____ behavior, such as walking.

neural 1464. When we take a step, the contraction of muscles in our legs sends afferent _____

impulses; stem _____ to the brain _____.

efferent 1465. Immediately, on receipt of these afferent neural impulses, the brain stem sends _____ neural impulses back down to the muscles causing them to contract again so that the next step may be taken.

brain stem 1466. We have seen that all afferent neural impulses, which ascend the spinal cord, enter the _____.

muscles 1467. From the brain stem, the impulses frequently go back down the spinal cord to cause the contraction of _____.

cranial 1468. We previously saw that the majority of afferent neural impulses enter the brain stem regardless of whether they ascend the spinal cord or are conducted directly into this part of the brain by _____ nerves.

reticular 1469. On entering the brain stem, nerve impulses may go in either of two directions. For one, they may enter the _____ activating system.

brain stem 1470. Or they may bypass the reticular activating system and go through other parts of the _____.

stem 1471. Recall that the internal structure of the brain called the thalamus, is located directly above the brain _____.

brain stem 1472. Nerve impulses that bypass the reticular activating system go directly to the thalamus when they leave the _____.

cortex 1473. We also saw that nerve impulses that leave the reticular activating system eventually end up in the cerebral _____.

nerve impulses 1474. While on their way from the reticular activating system to the cortex, these _____ go through the thalamus.

1475. Therefore, we can say that all nerve impulses that leave the brain stem enter the internal structure of the brain called the thalamus.

1476. Impulses that leave the brain stem go higher into the internal part of the brain called the thalamus.

1477. When the thalamus receives nerve impulses from the brain stem, it directs those nerve impulses to various parts of the cortex. It can thus be seen that the thalamus acts as a switching, or relay, station.

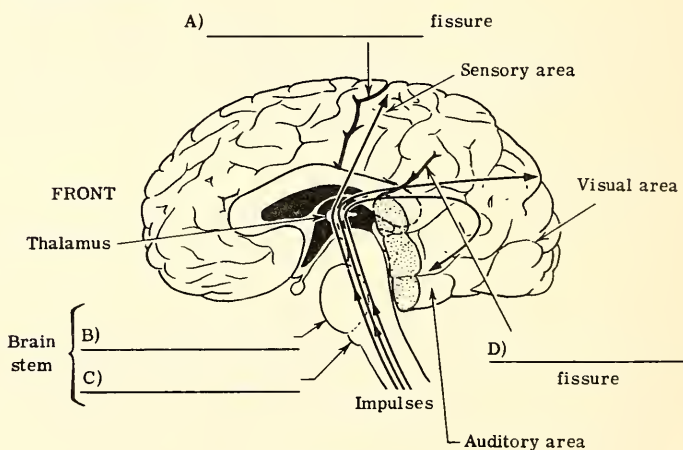


FIGURE 72

- A. Central
- B. Pons
- C. Medulla
- D. Lateral

1478. Fill in the blanks in Figure 72.

1479. In Figure 72, we see how the thalamus directs nerve impulses to various parts of the cerebral cortex.

1480. Like the brain stem, the thalamus contains several very specific nervous CENTERS. Neural impulses from the eye, for example, arrive at the nervous center in the thalamus for vision.

1481. When these visual nerve impulses arrive at the visual center of the thalamus, they are then directed to the visual area of the cerebral _____.

cortex

1482. Name the four lobes of each cerebral hemisphere. At the very front of the brain, one finds the _____ lobe; immediately behind the central fissure, one finds the _____ lobe; directly below the lateral fissure, one finds the _____ lobe; and at the very back of the brain, one finds the _____ lobe.

frontal
parietal
temporal
occipital

1483. In Figure 72, you can see that the visual area of the cortex is in the back part of the brain. Hence, you know that the visual area of the cortex lies in the _____ lobe.

occipital

1484. Nerve impulses from the eye are conducted into the brain along the _____ nerve called optic nerve.

cranial

1485. When these visual nerve impulses leave the cranial nerve, called the _____ nerve, they eventually enter the thalamus.

optic

1486. More specifically, visual nerve impulses enter the visual center of the _____.

thalamus

1487. From the thalamus, the impulses are then directed to the visual area of the cortex, which is located in the _____ lobe.

occipital

1488. The occipital lobe contains the _____ area.

visual

1489. Auditory nerve impulses from the ear are conducted into the brain stem along the cranial nerve called the _____ nerve.

auditory

- thalamus* 1490. The thalamus also contains an auditory center. From the brain stem, auditory nerve impulses enter the auditory center in the _____.
- auditory center* 1491. From the _____ of the thalamus, these impulses are directed to the auditory area of the cortex.
- lateral* 1492. As can be seen in Figure 72, the auditory area of the cortex lies in the lobe below the _____ fissure.
- temporal* 1493. Hence, we may say that the auditory area of the cortex is in the _____ lobe.
- auditory* 1494. The temporal lobe contains the _____ area.
- cortex* 1495. The thalamus also contains a center that receives nerve impulses from all over the body. It then directs these nerve impulses to that part of the cerebral _____ called the SENSORY AREA.
- central* 1496. Note, in Figure 72, that the sensory area is immediately behind the _____ fissure.
- sensory* 1497. The area of the cortex directly behind the central fissure, and thus lying within the parietal lobe, is called the _____ area.
- parietal* 1498. Because the sensory area of the cortex lies immediately behind the central fissure, we know that the sensory area is in the _____ lobe.
- kinesthetic* 1499. We previously saw that the cutaneous and the kinesthetic receptors are widely distributed throughout the body. When the cutaneous and _____ receptors are stimulated, they send nerve impulses up the spinal cord and into the brain stem.

1500. From the brain stem, these cutaneous and kinesthetic nerve impulses next go to a center in the *thalamus* _____.

1501. The *thalamus* then directs such impulses from the cutaneous and kinesthetic receptors to the part of the cortex called the _____ area.

1502. The sensory area of the cortex lies immediately behind the _____ fissure and receives nerve impulses from _____ receptors and from _____ receptors.
(*central cutaneous kinesthetic either order*)

1503. Nerve impulses from cutaneous and kinesthetic receptors ascend the spinal cord, go through the brain stem, enter a particular center in the _____, and finally end up in the _____ of the cortex.
(*thalamus sensory area*)

1504. We thus see that afferent neural impulses, whether they come from the eye, the ear, the cutaneous or the kinesthetic receptors, etc., are directed to specific areas of the cerebral _____ by the internal structure of the brain called the _____.
(*cortex thalamus*)

1505. Now let us summarize and extend what we have learned so far.

✓ 1506. We have seen how afferent neural impulses typically enter the brain stem. If they come from spinal nerves, they ascend the _____.
(*spinal cord*)

1507. Or they may come directly into the brain stem from _____ nerves.
(*cranial*)

1508. Once nerve impulses enter the brain stem, they either go into the reticular activating system, or they go through other parts of the brain stem, thus bypassing the _____ system.

1509. When the impulses enter the reticular activating system, a number of diffuse impulses are then sent to activate the _____.

1510. All nerve impulses that leave the brain stem, next go to the _____.

1511. Regardless of whether or not nerve impulses leave the reticular activating system, or whether they leave other parts of the brain stem, they all next go to the _____.

1512. The thalamus, then, acts like a switching station, in that it switches or directs the nerve impulses to specific areas of the cerebral _____.

1513. For example, nerve impulses that come from the ear are conducted along the auditory nerve into the brain stem and then into the auditory center of the internal structure of the brain called the _____.

1514. The _____ center of the thalamus then directs these nerve impulses from the ear into the _____ area of the cerebral cortex.

1515. The temporal lobe of the cerebral cortex contains the _____ area.

1516. The auditory area of the cerebral cortex lies in the _____ lobe.

1517. We know that the cerebrum is divided into _____ cerebral hemispheres.

- four* 1518. We know too, that each cerebral hemisphere has _____ lobes.
- occipital* 1519. Thus, each cerebral hemisphere has a temporal lobe, a frontal lobe, a parietal lobe, and an _____ lobe.
- auditory* 1520. In general, the thalamus directs an incoming neural impulse to BOTH cerebral hemispheres. For instance, an impulse that enters the thalamus from the auditory nerve goes to the _____ area of the temporal lobe in the left cerebral hemisphere.
- right* 1521. It also goes to the auditory area of the temporal lobe in the _____ cerebral hemisphere.
- temporal* 1522. Auditory neural impulses go to both cerebral hemispheres. More particularly, they go to the auditory area located in the _____ lobe of both cerebral hemispheres.
- optic* 1523. When a nerve impulse comes from the eyes, along the cranial nerve called the _____ nerve, the thalamus directs that impulse to both cerebral hemispheres.
- occipital* 1524. More specifically, that visual impulse is directed to the visual area that lies in the _____ lobe of each cerebral hemisphere.
- visual* 1525. Each of the two occipital lobes receives visual nerve impulses in the area of the cortex called the _____ area.
- optic*
visual 1526. When a visual stimulus, such as a red light, excites the eyes, a nerve impulse is transmitted along the _____ nerve into the visual center of the thalamus and thence to the _____ areas of the cortex in both occipital lobes.

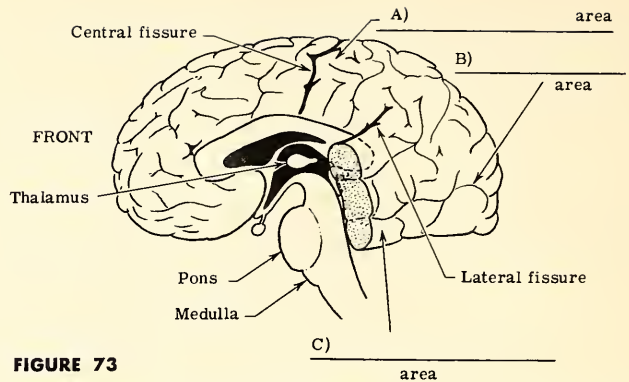


FIGURE 73

- A. Sensory area
- B. Visual area
- C. Auditory area

1527. Identify each of the three areas of the cortex, shown in Figure 73, by filling in the blanks.

1528. Although we are not sure, it is widely believed that a person is “conscious” of a visual stimulus, such as a red light, when the resulting nerve impulse finds its way into the _____ area of the cortex.

1529. Similarly, a person seems to be conscious of an auditory stimulus when the resulting impulse finds its way into the _____ of the cortex contained in the _____ lobe.

1530. The activation of neurons in the visual area, by incoming visual impulses, seems to make us conscious of external _____ stimuli.

1531. What would happen if the visual area were electrically stimulated? When surgeons have stimulated the _____, the individuals have reported visual experiences such as flashing lights or whirling colors.

1532. Similarly, when one of the two AUDITORY areas is electrically stimulated, the patient reports _____ experiences such as hearing humming or buzzing sounds.

1533. The sensory area of the cortex lies in the _____ lobe immediately behind the _____ fissure.

parietal
central

1534. When a small electrical stimulus is applied to the area behind the central fissure, called the _____ area, the patient reports various kinds of body "feelings," such as "My leg feels warm," or "I have a funny tingling sensation in my arm," or "I feel like my hand is moving" (even though it really is not moving).

sensory

1535. If the sensory area in a person's right cerebral hemisphere is stimulated, nerve impulses descend the spinal cord and cross over to the opposite side of the body. Thus, stimulation of the sensory area in the right cerebral hemisphere produces feelings in the _____ side of the body.

left

1536. We saw that ascending nerve impulses cross over the spinal cord to the *OPPOSITE* side. In like manner, descending neural impulses cross the spinal cord, at some level, to the _____ side of the body.

opposite/other

1537. Thus, stimulation of the left sensory area will produce feelings in the _____ side of the body.

right

1538. Nerve impulses that come from the left side of the body cross over to the opposite side of the spinal cord and go to the _____ cerebral hemisphere.

right

1539. Thus, if a person is stuck with a pin in his left arm, the resulting "conscious" sensation would occur when nerve impulses arrive in the part of the cortex, called the _____ area, of his right cerebral hemisphere.

sensory

1540. Nerve impulses that descend from the right cerebral hemisphere, cross over the spinal cord and go to the _____ side of the body.

left

1541. Thus, if a person's sensory area in the right cerebral hemisphere is stimulated, the resulting bodily sensation would be localized, or felt, in the _____ side of his body.

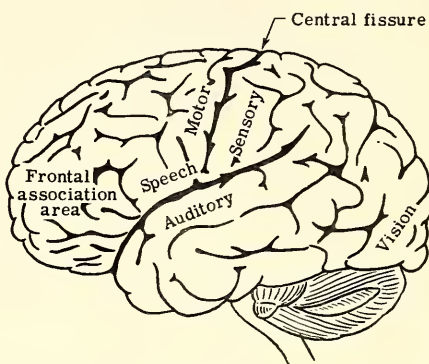


FIGURE 74

1542. In Figure 74, we see a diagram of the cortex of the left cerebral hemisphere. There we see that the auditory area is in the _____ lobe, that the sensory area is in the _____ lobe, and that the occipital lobe contains the area for _____.

1543. In Figure 74, we also see that the FRONTAL ASSOCIATION AREAS are located in the _____ lobes.

1544. The frontal association _____ are especially well developed in man.

1545. What is the function of the _____ association areas?

1546. Unfortunately, we do not have a complete answer to this question. The little research that has been conducted on the frontal _____ suggests that one function is related to attention.

1547. For example, when the frontal association areas of monkeys were extirpated, the monkeys could not maintain their attention to a task. Such results suggest that the frontal association areas function to help us maintain _____.

attention

1548. One function of the _____ association areas seems to be to help us maintain _____.

frontal
attention

1549. Humans who have had their frontal association areas damaged seem to have difficulty in maintaining _____.

attention

1550. Such people also appear to not worry about FUTURE events. Individuals who have accidentally had their frontal association areas damaged appear to have lost much of their concern for _____ events.

future

1551. Poor ability to make plans about the future seems to result from destruction of the _____.

frontal
association areas

1552. Making plans necessarily involves the anticipation of FUTURE events. Although the results of research are not clear, they suggest that the frontal association areas contribute to man's ability to anticipate _____ events.

future

1553. Although much more research needs to be conducted, what little information we have suggests that the frontal association areas are important for maintaining _____, and for anticipating _____ events.

attention
future

1554. In Figure 74, you can note that the frontal lobe also contains a SPEECH AREA. The normal functioning of the speech _____ is necessary in order for us to talk.

area

frontal 1555. The speech area is located in the _____ lobe.

speech 1556. People who have lesions in the part of the frontal lobe that contains the _____ area have SPEECH APHASIA (ə fā'zhə).

speech 1557. The loss of ability to speak a language is called _____ aphasia.

*speech
aphasia* 1558. If an otherwise normal person is unable to speak, we might suspect that he has _____.

speak/talk 1559. A person who has speech aphasia is able to understand spoken language, but he himself is not able to _____.

*speech area
cerebral* 1560. Unlike the other areas of the cortex, the speech area does not appear in both cerebral hemispheres. Rather, the _____ appears only in the left _____ hemisphere.

*frontal; speech
aphasia* 1561. If a person has a lesion in the portion of his _____ lobe called the _____ area, he will develop speech _____.

*association areas
speech* 1562. We can thus see that the frontal lobes are extremely important. They contain the frontal _____ and the _____ area.

*future
attention* 1563. The frontal association areas seem to contribute to our ability to plan _____ events, and to maintain _____.

speak/talk 1564. The speech area is responsible for our ability to _____.

1565. In Figure 74, we see that the motor area lies directly in front of the _____ fissure.
central
1566. The sensory area is immediately in back of the central fissure, and the _____ is immediately in _____ of the central fissure.
motor area front
1567. The neurons in the motor area extend down to neurons in the brain stem and the spinal cord that eventually connect to muscles. Nerve impulses from the _____ area thus find their way to muscles throughout the body.
motor
1568. If a particular place in a person's motor area is electrically stimulated, there results a contraction of muscles at a specific location in his body. For example, stimulation of a specific part of the _____ might cause movement of the hand.
motor area
1569. Stimulation applied in another part of the motor area would cause MOVEMENT of the toes, whereas stimulation in still another part of the _____ area would cause _____ of the lips.
motor movement
1570. Neurons from the left hemisphere cross over to the right side of the body as they descend the brain and spinal cord. Therefore, stimulation of the motor area in the left cerebral hemisphere produces movement in the _____ side of the body.
right
1571. Stimulation of the motor area in the right cerebral hemisphere produces _____ in the _____ side of the body.
movement left
1572. If a person has a lesion in the motor area of the left cerebral hemisphere, a paralysis develops in the _____ side of his body.
right
1573. The motor area is a specific region in the cerebral _____ of both cerebral hemispheres.
cortex

motor area 1574. Whereas the speech area is located in the left cerebral hemisphere, the area directly in front of the central fissure, called the _____, appears in both cerebral hemispheres.

central fissure 1575. The motor area is located directly in front of the _____.

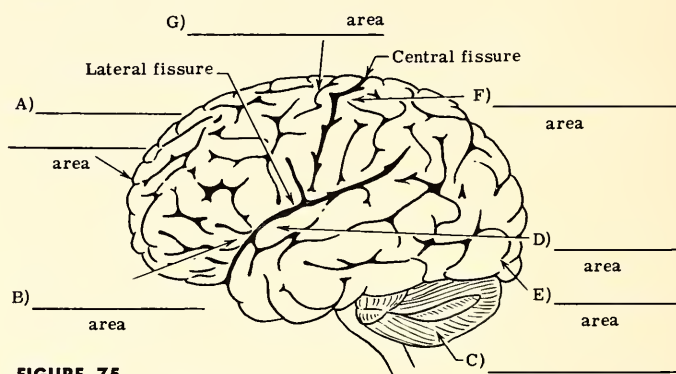


FIGURE 75

- A. Frontal association area
- B. Speech area
- C. Cerebellum
- D. Auditory area
- E. Visual (or vision) area
- F. Sensory area
- G. Motor area

1576. Fill in the blanks to indicate the various parts of the brain.

brain

1577. A number of sections of the brain are concerned with the control of muscles. These sections of the _____ are connected together, either directly or indirectly, by means of groups of neurons.

muscles

1578. In studying the kinesthetic sense, we saw that nerve impulses go from muscles to the brain stem, and from the brain stem back to the _____.

motor

1579. We have also seen how the muscles on the right side of the body are controlled by the _____ area of the cerebral cortex, which is located in the left cerebral hemisphere.

motor brain 1580. In addition to the _____ area of the cortex and the _____ stem, the CEREBELLUM is a third section of the brain that is intimately concerned with motor control.

cerebellum 1581. The sponge-like structure below the back of the cerebrum, called the _____, has widespread neural connections with the brain stem and the motor area of the cortex.

brain; motor cerebellum 1582. Three parts of the brain are intimately concerned with motor control of the muscles. These are the _____ stem, the _____ area of the cortex, and the _____.

cerebellum 1583. Not only do the nerve impulses, which come from kinesthetic receptors, find their way to the brain stem and to the cortex, they also go to the _____.

responses/ movements 1584. The cerebellum receives these impulses and integrates them so that a series of smooth, coordinated responses result. A lesion in the cerebellum would result in a series of jerky RESPONSES, rather than in a series of smooth, integrated _____.

cerebellum 1585. Highly skilled and integrated responses depend, in large part, on the cerebellum. The highly developed movements of a bird in flight are possible because a bird has a relatively large and well developed _____.

cerebellum brain; motor 1586. The cerebellum works closely together with various other portions of the brain concerned with motor control. Among the areas of the brain concerned with motor control are the _____, the _____ stem, and the _____ area of the cortex.

responses/
movements/
behavior

1587. As a result of the close cooperation of such portions of the brain, a person is able to make series of well coordinated, integrated _____.

functions

1588. The brain is an exceedingly complex organ. Many of the FUNCTIONS of the brain have not been considered here, and, in fact, many of its functions are yet to be discovered. A consideration of two more _____ of the brain will conclude our present discussion of it.

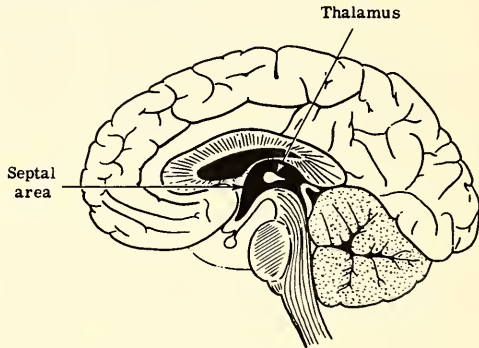


FIGURE 76

area

1589. In an interesting experiment, using white rats, tiny electrodes were inserted into an area of the brain called the septal area. As you can see in Figure 76, the septal _____ is close to the thalamus.

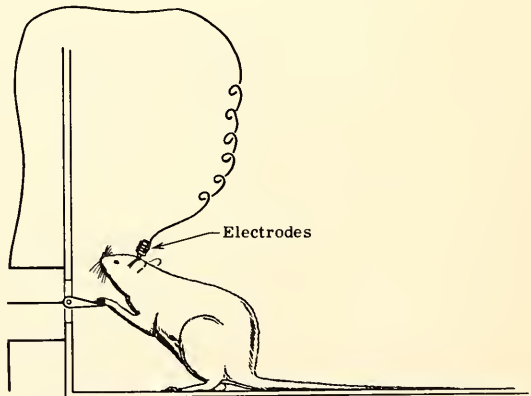


FIGURE 77

1590. In Figure 77, we see a diagram of the rat pressing the lever. Every time he pressed the lever a small amount of electricity would go through the wires into the electrode and into the internal part of his brain called the _____.

septal area

1591. The rat was then “free” to press the lever or not to press the lever. Every time he pressed the lever a small amount of _____ was delivered to his _____ area.

electricity
septal

1592. The fascinating finding of this experiment was that the rat pressed the lever a large number of times. The conclusion was that shocking himself in the _____ was a “pleasant” (rewarding) experience for the rat.

septal area

1593. Because stimulation of the septal area seemed to provide a REWARD (a “pleasant experience”), that center has been called a _____ center.

reward

1594. The _____ is a _____ center.

septal area; reward

1595. The second interesting function that we will discuss concerns memory for past experiences. A surgeon, while performing a necessary operation, electrically stimulated several places in a patient’s cerebral cortex. Stimulation of some of the places of the cerebral _____ produced a vivid MEMORY, or recall of past experiences.

cortex

1596. For example, when a specific place in the cortex of the TEMPORAL LOBE was electrically _____, the patient said, “Yes, sir, I think I heard a mother calling her little boy somewhere. It seemed to be something that happened years ago.”

stimulated

1597. Experiments such as these suggest that the brain stores memories of past events. In this example, stimulation of a particular part of the temporal lobe produced a vivid _____ of a past event.

memory

1598. The results of this investigation indicated that a person can recall a past event when a special place in the _____ lobe of the cortex was stimulated.

temporal

1599. Let us now summarize the process by which a nerve impulse is conducted from a receptor to an effector.

✓ 1600. When a receptor in the body sets off an afferent neural impulse, that impulse is conducted along a spinal nerve into a _____ root of the spinal cord.

dorsal

1601. The impulse then may go in two directions: 1) out of the spinal cord through a _____ root to activate an effector; and 2) up the spinal cord into the lower part of the brain called the _____.

ventral

*brain
stem*

1602. Afferent neural impulses always cross over the spinal cord and go to the cerebral hemisphere on the opposite side of the body. In like manner, impulses that descend from one cerebral hemisphere cross over to the _____ side of the body.

opposite, or other

1603. Thus, afferent neural impulses from the left side of the body go to the _____ cerebral hemisphere, and nerve impulses that come from the left cerebral hemisphere control the _____ side of the body.

right

right

1604. If an afferent neural impulse is generated by a receptor in the head (e.g., the eyes), the impulse is transmitted along one of the _____ nerves, called the optic nerve, directly to the brain.

cranial

reticular activating

1605. When an afferent neural impulse enters the brain stem it may go in either of two directions: 1) into the _____ system; or 2) it may bypass this region and go to other parts of the brain stem.

cortex

1606. Neural impulses that enter the reticular activating system produce a diffuse discharge of impulses that activates the cerebral _____.

activate/stimulate

1607. The cerebral cortex, in turn, sends impulses down to _____ the reticular activating system.

thalamus

1608. When an incoming neural impulse leaves the brain stem, it next enters one of several specific nervous centers in the internal part of the brain called the _____.

cortex

1609. The thalamus acts as a switching, or relay, station to direct these impulses to various areas of the cerebral _____.

*auditory
brain*

1610. For example, a nerve impulse from the ear runs along the cranial nerve, called the _____ nerve, directly into the _____ stem.

auditory

1611. The brain stem then sends the auditory impulse into the _____ center of the thalamus.

*auditory
temporal*

1612. From the auditory center of the thalamus, the impulse goes to the _____ area of the cortex that is located in the _____ lobe.

cerebral cortex

1613. Neural impulses relayed from the thalamus are directed to a large number of areas of the _____.

1614. For example, they may be directed to the area
visual in the occipital lobe called the _____ area, or
 to the sensory area that is directly behind the
central; parietal _____ fissure in the _____
 lobe.

1615. Well integrated motor control involves making a series of coordinated responses. The integration of responses is controlled by various parts of the brain, such as the motor area, that lies directly in front of the _____, by the brain stem, and by the rather large sponge-like structure below the occipital lobe called the _____.
central fissure
cerebellum

1616. The speech area is a particularly important area in the frontal lobe of the _____ cerebral hemisphere.
left

1617. When nerve impulses descend from the brain, they leave the spinal cord by means of the _____ roots.
ventral

1618. Impulses conducted out of the spinal cord by means of ventral roots, are transmitted along efferent nerves to one of the two types of effectors: _____ or _____.
muscles; glands

THE NERVOUS SYSTEMS

Section XIV: The Peripheral Nervous System

1619. We have described the nature of the central nervous system. The brain and the spinal cord compose the _____.

*central
nervous system*

1620. We have used the term "nervous systems" several times. We did this because there is more than one nervous _____ in the body.

system

1621. The central nervous system is made up of the _____ and the _____.

brain; spinal cord

1622. All other nervous material compose the peripheral nervous _____.

system

1623. That is, all nervous material outside of the _____ system makes up the PERIPHERAL NERVOUS SYSTEM.

central nervous

1624. To be more precise, we should say that the central nervous system includes all the nervous material within the cranium and the _____.

*spinal
cord*

1625. Because certain cranial nerves, such as the optic nerve, are encased entirely in the cranium, they belong to the _____.

*central nervous
system*

1626. Other cranial nerves, however, extend outside of the cranium, to regions of the face, for example. Hence, some cranial nerves belong exclusively to the central nervous system while portions of other cranial nerves belong to the _____ nervous system.

peripheral

1627. In general, all nervous material that lies outside of the cranium and the _____ belong to the _____ system.

spinal cord
peripheral nervous

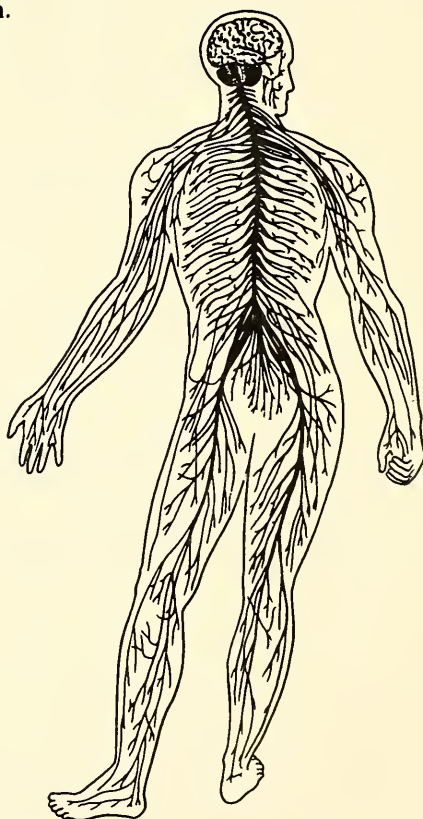


FIGURE 78

1628. In Figure 78, we see a representation of the nervous systems from a rear view. Note that all nerves throughout the body connect to the nervous material, in the central part of the body, that makes up the _____.

central nervous
system

peripheral 1629. In this simplified representation of the nervous systems you can get some idea that, like the central nervous system, the _____ nervous system is also very complex.

efferent 1630. The general function of the peripheral nervous system is to conduct afferent neural impulses into the central nervous system and to conduct _____ neural impulses out of the central nervous system.

spinal 1631. The nerves that enter the dorsal root and leave the ventral root of the spinal cord, are called _____ nerves.

cranial 1632. But the nerves that enter and leave the brain are called _____ nerves.

cranial; spinal 1633. The peripheral nervous system includes _____ and _____ nerves that lie outside of the central nervous system.

receptors 1634. As the cranial and spinal nerves move farther away from the central nervous system, they branch and divide into numerous smaller nerves. These smaller nerves receive neural impulses that are generated by _____ distributed throughout the body.

effectors 1635. In addition to transmitting nerve impulses from receptors to the central nervous system, these smaller nerves also deliver efferent neural impulses to _____ that are widely distributed throughout the body.

nervous system 1636. The peripheral nervous system has two divisions: 1) the AUTONOMIC ($\hat{o}$ tə nŏm'ĭk) nervous system, and 2) the SOMATIC _____.

peripheral 1637. Like the somatic nervous system, the autonomic nervous system is part of the larger _____ nervous system.

autonomic 1638. Note that it is called the autonomic and not the automatic nervous system: Write "autonomic," but do not write "automatic" _____.

efferent 1639. The autonomic nervous system is entirely MOTOR in function. That is, it does NOT conduct afferent neural impulses into the central nervous system, but only conducts _____ neural impulses out of the central nervous system to effectors.

efferent 1640. The autonomic nervous system sends _____ neural impulses to various internal organs of the body, such as the heart, the glands, and blood vessels.

autonomic 1641. The contraction of the muscles in the stomach, which is necessary when we digest food, is an example of an internal organ that receives efferent neural impulses by means of the part of the peripheral nervous system called the _____ nervous system.

autonomic nervous 1642. The intestines is another example of an internal ORGAN that is controlled by the _____ system.

organs 1643. When a person is in an EMOTIONAL STATE, one thing that happens is that the various internal _____ of the body become "stirred up."

autonomic 1644. Changes in the action of the internal organs of the body during emotional states is due to increased activity of the _____ nervous system.

emotional 1645. The autonomic nervous system is especially active when a person is in an _____ state.

right 1646. Man has two ADRENAL glands, one located on the left side of the body, at about the waist line, and the second is located in the same place on the _____ side of the body.

autonomic emotional 1647. As a specific example of how the _____ nervous system acts when man is in an _____ state, consider how the internal part of the adrenal glands functions.

adrenal 1648. When a man becomes frightened, the autonomic nervous system delivers neural impulses to the internal part of the _____ glands.

adrenal 1649. When the internal part of the _____ glands are stimulated, they secrete a product called ADRENALIN into the blood system.

adrenal glands 1650. Adrenalin, secreted by the _____, is distributed throughout the body by means of the blood vessels.

adrenalin 1651. The receipt of adrenalin in various parts of the body helps to prepare man to meet a frightening situation. For example, when the liver receives _____ by means of the blood stream, it releases more BLOOD SUGAR.

blood 1652. When the blood stream receives an increased amount of _____ sugar, the man has more energy with which to fight or run.

afferent 1653. Consider a man who sees a bear coming at him. The eyes generate _____ neural impulses that are conducted through the central nervous system.

autonomic 1654. Efferent neural impulses are then received by the part of the peripheral nervous system called the _____ nervous system.

efferent 1655. The autonomic nervous system conducts these _____ neural impulses to various internal organs of the body.

1656. The increased activation of these internal
organs _____ of the body helps the man to meet the
 emergency situation.

1657. For example, efferent neural impulses are con-
 ducted to the internal part of the adrenal glands. This
adrenal increased activity of the _____ glands pro-
adrenalin duces an increase in the amount of _____
 released into the blood stream.

1658. The adrenalin is then widely distributed so
 that various parts of the man's body are better pre-
 pared to meet the emergency situation. For example,
 the adrenalin activates the liver to release more blood
sugar _____, thus giving the man an increased
 amount of energy.

1659. When an increased amount of blood sugar
 reaches the muscles of the arms and legs, the man has
energy an increased amount of _____ with which to
 respond.

1660. To consider another characteristic of the
autonomic _____ nervous system, note that the
 internal organs of the body function in an AUTOMATIC
 fashion.

1661. It is the autonomic nervous system that allows
automatic these internal organs to function in an _____
 fashion.

1662. For example, a person does not "decide" that
 his heart will beat, that he will sweat, or that he will
 digest his food. Rather, these internal functions are
automatic carried out in an _____ fashion by the
 autonomic nervous system.

1663. Recall that we said there is a center in the
medulla MEDULLA that controls heart rate. The neural impulses
autonomic from the heart rate center in the _____ are
nervous conducted to the heart by means of the _____
 _____ system.

autonomic 1664. The integration of the heart rate center in the medulla, with the heart, by means of the _____ nervous system, allows the heart to beat continually in an _____ fashion.

peripheral 1665. To briefly summarize what we have said about the autonomic nervous system, recall that it is one of two divisions of the _____ nervous system.

from organs 1666. The autonomic nervous system does NOT deliver neural impulses to the central nervous system. Rather, it transmits impulses _____ the central nervous system to the internal _____ of the body.

automatic 1667. The autonomic nervous system controls the functioning of the internal organs of the body in an _____ fashion.

emotional 1668. It also is especially active when man is in an _____ state.

autonomic 1669. The peripheral nervous system may be divided into two parts: 1) the SOMATIC NERVOUS SYSTEM, and 2) the _____ nervous system.

somatic 1670. The autonomic nervous system serves the glands and internal organs of the body, whereas the _____ nervous system serves the receptors and the kinds of muscles required for walking, talking, writing, etc.

somatic 1671. The word "somatic" derives from the Greek *somatikos*, meaning "the body." The _____ nervous system is widely distributed throughout the body.

efferent 1672. The autonomic nervous system is efferent in nature only, but the somatic nervous system is BOTH afferent and _____ in nature.

somatic nervous

1673. That is, nerve impulses generated by receptors are conducted to the central nervous system by means of spinal, and portions of cranial, nerves that are part of the _____ system.

*spinal
somatic*

1674. Similarly, nerve impulses conducted out of the central nervous system are transmitted to muscles used in such activities as running or shaking hands, by means of the cranial or _____ nerves that are part of the _____ nervous system.

automatic

1675. Whereas the autonomic nervous system functions in an _____ fashion, the somatic nervous system functions in a more "voluntary" fashion.

decide

1676. For example, one does not decide that he is going to secrete adrenalin, but one could _____ that he will raise his right hand.

muscles

1677. A so-called "voluntary" act, such as raising your right hand, results from the transmission of neural impulses from the central nervous system to muscles in the right arm. When these impulses are received in the right arm, _____ contract and the right arm is raised.

voluntary

1678. By the term "voluntary" act, or response, we mean that the person can talk about the response before he performs it. That is, he can say to himself or to others that he has just "decided" to raise his right hand. When a person can say that he is going to perform a response before he actually performs it, we can say that the response is a _____ response.

voluntary

1679. If a person can tell us that he is going to make a response, then we may call that response a _____ response.

voluntary 1680. On the other hand, if the person cannot talk about the response (either to himself or to others) before he makes it, we would not refer to that response as a _____ response.

automatic 1681. When a person cannot talk about a response before he makes it, we say that the response is automatic, rather than voluntary. The only difference between the physiology of voluntary and _____ responses is that the voluntary response is more complex.

automatic 1682. Voluntary responses are of the same nature as _____ responses, but they are physiologically more complex.

automatic 1683. The important point is that when we talk about voluntary responses we do not mean to suggest that they are caused by "mental energy," or by the "will." Thus, voluntary responses are merely more complex than _____ responses—both types are produced by nerve impulses.

afferent 1684. The somatic nervous system delivers _____
efferent neural impulses from receptors to the central nervous system and _____ neural impulses from the central nervous system to muscles.

effectors 1685. To better understand the nature of the effectors activated by the autonomic nervous system and by the somatic nervous system, let us now study these _____ that are distributed throughout the body.

EFFECTORS

Section XV: Muscles

effectors 1686. Efferent neural impulses may activate one of the two major types of _____: muscles or glands.

muscle; gland 1687. When an efferent neural impulse activates an effector, be it a _____ or _____, we say that a **RESPONSE** results.

response 1688. For example, when a muscle contracts, we say that the organism has made a _____.

gland 1689. A response is also made when a _____ secretes its product.

muscle 1690. In a way, a nerve is similar to a muscle. That is, a nerve is a bundle or collection of tiny nerve fibers, and a **MUSCLE** is a bundle or collection of tiny _____ fibers.

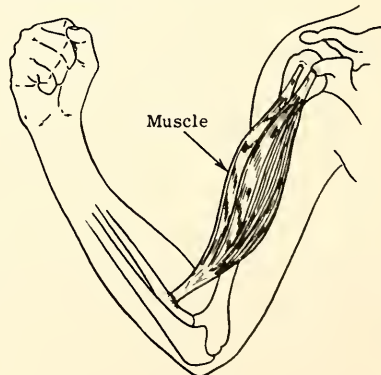


FIGURE 79

1691. In Figure 79, we see a number of muscle fibers that are collected, or bound together to form a muscle.



A muscle fiber

FIGURE 80

1692. In Figure 80, we see a diagram of one kind of muscle fiber.

1693. When a nerve impulse arrives at a muscle, it causes a number of muscle fibers to contract. This is because a single efferent nerve fiber joins several muscle fibers.

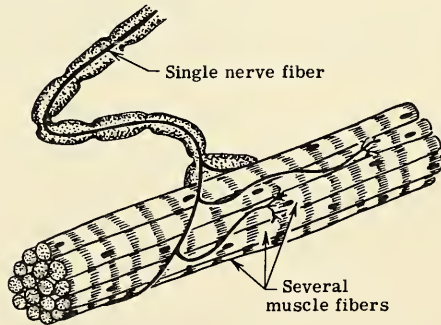


FIGURE 81

1694. In Figure 81, we see an example of how a single nerve fiber makes junction with several muscle fibers.

1695. Thus, an efferent neural impulse that runs along a single neuron, causes a number of muscle fibers to contract.

1696. Let us now see just what happens when a muscle fiber receives an efferent neural impulse.

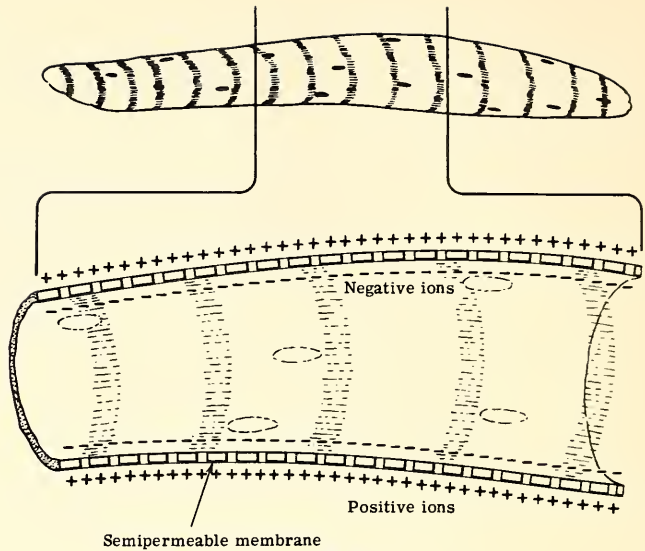


FIGURE 82

1697. In the top of Figure 82, we see a diagram of a single muscle fiber. Just like the neuron, the muscle fiber is encased in a semi-permeable membrane.

1698. In the lower part of Figure 82, we see an enlarged diagram of a portion of a muscle fiber. Like the resting neuron, the resting muscle fiber has positive ions on the outside of the semi-permeable membrane.

1699. In Figure 82, we see that in the normal resting state the muscle fiber has positive ions on the outside of its semi-permeable membrane and negative ions on the inside of its semi-permeable membrane.

1700. When a nerve impulse arrives at a muscle fiber, this "balance" between positive ions on the outside and negative ions on the inside is disturbed.

1701. The disturbance of the balance causes the positive ions to move through tiny holes to the inside of the semi-permeable membrane.

1702. When this balance between positive and negative ions is disturbed by the arrival of an *efferent* _____ neural impulse, the muscle fiber contracts.

1703. Because each efferent nerve fiber connects to SEVERAL muscle fibers, the arrival of a single efferent neural impulse causes several muscle fibers to *contract* _____.

1704. The arrival of an efferent neural impulse at a group of muscle fibers causes the positive ions on the *outside* _____ of the semi-permeable membrane of each muscle fiber to move to the inside where they *negative* come in contact with _____ ions.

1705. When this balance between positive and negative ions is disturbed, each muscle fiber connected to the efferent neuron starts to *contract* _____.

1706. Each muscle contains a large number of muscle fibers. Furthermore, a number of _____ *efferent* neurons connect with each muscle.

1707. When a number of nerve impulses arrives at a muscle along the various efferent nerve fibers, they *contract* cause a large number of muscle fibers to _____.

1708. Thus, the whole muscle contracts when all of its muscle fibers are caused to contract by the arrival *efferent* of a number of _____ neural impulses.

1709. Just as in the case of the neuron, the flow of positive ions to the inside of the semi-permeable membrane generates "electricity." Hence, when a muscle *electricity* fiber contracts, a certain amount of _____ is generated.

- contracts* 1710. When a neuron fires, we can measure the amount of electricity that flows through it. In like manner, when a muscle fiber fires, or more precisely, when it _____, there is a measurable amount of electricity generated.
- negative* 1711. When a nerve impulse arrives at a muscle fiber, the balance between positive and _____ ions is disturbed.
- electricity contracts* 1712. At this time, the positive ions move to the inside of the semi-permeable membrane, and _____ is generated as the muscle fiber _____.
- all* 1713. The All or None Law applies to the muscle fiber, as well as to the neuron. Thus, if a muscle fiber contracts, it will give off _____ its energy.
- none* 1714. If the muscle fiber fails to contract, _____ of its energy is given off.
- muscle* 1715. The All or None Law applies to both neurons and _____ fibers.
- inside* 1716. During contraction, the positive ions move to the _____ of the semi-permeable membrane.
- phase* 1717. As soon as a muscle fiber contracts, all its energy is expended and the recovery phase is started. The recovery _____ starts immediately after contraction.
- outside* 1718. It is during the recovery phase that the positive ions start to return to their original position _____ the semi-permeable membrane.
- contracts recovery phase* 1719. Positive ions move to the inside of the semi-permeable membrane when the muscle fiber _____, and they return to the outside during the _____.

1720. Once all of the positive ions have returned to the outside of the semi-permeable membrane, the muscle fiber is recharged and is again ready to "fire" or contract _____.

1721. Whereas all the muscle fibers in the body function in the general manner described above, there are three different types of _____ muscle fibers.

1722. The first type of _____ is that used in such activities as talking, running, and shaking hands.

1723. This first type of muscle fiber is called SKEL-ETAL muscle. Because it is attached to the bones, or skeleton, of the body, the first type of muscle fiber is called _____ muscle.

1724. The type of muscle that we feel just beneath our skin is used in activities such as walking or moving our hands. This muscle is attached to the bones of the body, and is called _____ skeletal muscle.

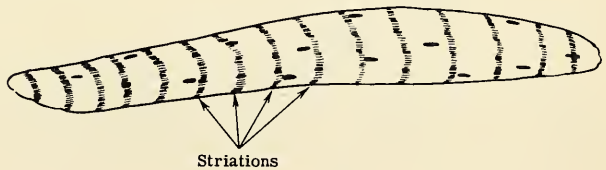


FIGURE 83

1725. In Figure 83, we can note the small stripes, or striations (threadlike lines), in a skeletal muscle fiber. Because skeletal muscle is STRIATED (stri'āt əd) sometimes it is called _____ muscle as well as _____ muscle.

1726. Another name for skeletal muscle is _____ striated muscle.

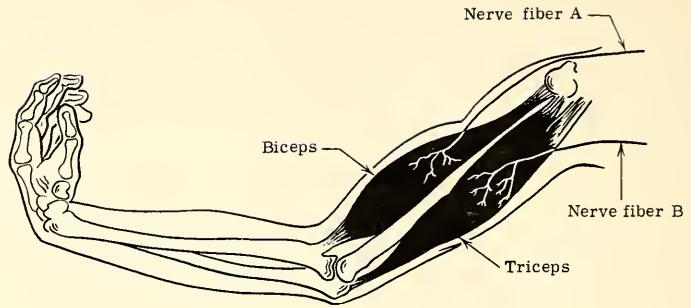


FIGURE 84

1727. In Figure 84, we see the well-known biceps (bī'sēps) and triceps (trī'sēps) muscles of the upper arm. Note that nerve fiber A connects to the biceps muscle _____.

1728. If nerve impulses run along nerve fiber A, they will cause the biceps muscle to _____.

1729. When the biceps muscle _____, it pulls on the bone of the lower arm.

1730. When the bone of the lower arm is pulled on by the _____ muscle, the lower arm moves up.

1731. The contraction of the biceps muscle pulls on the bone of the lower arm, thus causing the lower arm _____ to bend up at the elbow.

1732. Bending of the arm at the elbow is caused by the _____ of the _____ muscle.

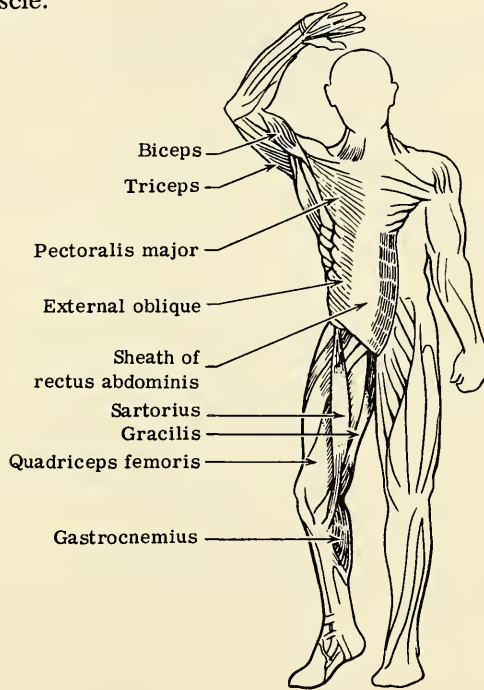
1733. Now suppose that nerve impulses arrive at the triceps muscle, along nerve fiber B. In this case the triceps muscle _____.

1734. When the triceps muscle _____, it pulls on the lower bone in the forearm, thus causing the arm to straighten out again.

1735. Bending the arm up is caused by the _____ of the biceps muscle, whereas straightening the arm is caused by the contraction of the _____ muscle.

skeletal/striated

1736. The biceps and triceps muscles are good examples of the type of muscle that we call _____ muscle.



skeletal/striated

1737. In Figure 85, we see a diagram of a number of skeletal muscles of the body. It is not necessary that you learn the names of all these muscles, but you can get a general idea of how the type of muscle, which we call _____ muscle, is distributed throughout the body.

skeletal/striated

1738. By the systematic contraction of _____ muscles throughout the body, we perform such activities as sitting, running, and talking.

system

1739. Recall that the somatic nervous _____ controls the type of muscle used in such activities as walking, running, talking, etc.

- skeletal muscles* 1740. We now know that muscles used for such activities are called _____.
- somatic nervous; skeletal* 1741. Hence, we may say that the _____ system controls the _____ muscles of the body.
- somatic* 1742. The so-called "voluntary" responses, such as "deciding" to raise your right hand above your head, are controlled by the _____ nervous system.
- contract* 1743. The somatic nervous system controls voluntary responses by causing the appropriate skeletal muscles to _____.
- voluntary* 1744. Because skeletal, or striated muscles are used in making VOLUNTARY responses, they are also sometimes called _____ muscles.
- skeleton/bones* 1745. Skeletal muscles are known by three different names. They are called skeletal muscles because they are attached to the _____ of the body.
- striated* 1746. Because they are striated, skeletal muscles are also known as _____ muscles.
- voluntary* 1747. The third name for skeletal muscles is due to their use in voluntary activities. Hence, they are also called _____ muscles.
- somatic skeletal; striated voluntary (any order)* 1748. The three names for the type of muscle controlled by the _____ nervous system are: 1) _____ muscles, 2) _____ muscles, and 3) _____ muscles.
- muscle* 1749. The first type of muscle is skeletal muscle, whereas the second type is smooth _____.
- striated* 1750. We saw that because it is striated, skeletal muscle is also called _____ muscle.

1751. A major distinguishing feature between skeletal muscle and smooth muscle is that skeletal muscle is striated, but smooth muscle is _____ striated.

1752. Because it lacks striations, and is thus smooth in appearance, the second type of muscle is called _____ muscle.

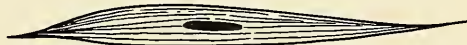


FIGURE 86

1753. In Figure 86, we see a diagram of a _____ fiber.

1754. Note that the smooth muscle fiber does not have _____.

A) _____ muscle fiber



B) _____ muscle fiber

FIGURE 87

1755. In Figure 87, we see the first two types of muscle. Label the type of each fiber in the blanks provided.

A. skeletal

B. smooth

1756. In Figure 87, you can see the _____ muscle fiber is larger than the _____ muscle fiber.

1757. Two ways to distinguish between skeletal and smooth muscle fibers are: 1) skeletal muscle fibers contain _____, whereas _____ muscle fibers do not; and 2) that _____ muscle fibers are smaller than _____ muscle fibers.

smooth 1758. The first two distinctions between skeletal and _____ muscle fibers concerns their structure.

function 1759. The third distinction concerns how they FUNCTION. Smooth and skeletal muscle fibers _____ somewhat differently when they contract.

smooth muscle 1760. For example, when a skeletal muscle fiber receives a nerve impulse, it contracts almost immediately. This is not the case with a _____ fiber.

smooth skeletal 1761. That is, it takes a longer time for _____ muscle to contract than it does for _____ muscle.

function 1762. The first two distinctions between skeletal and smooth muscle concerned their structure. The third distinction concerns how they _____ when they contract.

smooth skeletal 1763. One way in which they function differently is that _____ muscle contracts more slowly than does _____ muscle.

slowly 1764. Smooth muscle contracts more _____ than does skeletal muscle.

faster 1765. To put it the other way, skeletal muscle contracts more rapidly, or _____, than does smooth muscle.

smooth 1766. Another distinction between smooth and skeletal muscle concerns their location in the body. Skeletal muscle is distributed just beneath the skin, on the outside parts of the body, whereas _____ muscle tends to be more in the internal part of the body.

skeletal 1767. Muscles in the arms and legs are made up of _____ muscle.

1768. A number of internal organs of the body, however, contain _____ muscle.

smooth

1769. The stomach and intestines are examples of _____ organs of the body.

internal

1770. Internal organs of the body, such as the stomach and intestines, contain _____ muscle.

smooth

1771. The bladder is another example of an _____ organ that contains _____ muscle.

internal; smooth

1772. Because skeletal muscle contracts rapidly, movements or responses involving skeletal muscles are, themselves, rather _____.

rapid/fast

1773. The contraction of skeletal muscles produces _____ responses.

rapid/fast

1774. In contrast to skeletal muscle, however, _____ muscle contracts rather slowly.

smooth

1775. Thus, the contraction of smooth muscle results in rather _____ responses.

slow

1776. Skeletal muscle produces _____ responses, while smooth muscle produces _____ responses.

fast/rapid

slow

1777. For example, the movement of the arm can be quite fast, but responses of the stomach or intestines are rather _____.

slow

1778. A person may have to be very quick in jumping out of the way of a car, but he need not be so _____ in digesting his food.

quick/fast

1779. To get out of the way of a car, a person relies on the rapid, or fast, contraction of his _____ muscles.

skeletal

smooth 1780. However, in the more leisurely activity of digesting food, the relatively slow contraction of the _____ muscles in the stomach suffices.

smooth 1781. In addition to the internal organs, _____ muscle may be found in the blood vessels that are so widely distributed throughout the body.

blood contracts 1782. When the smooth muscle, contained in the _____ vessels, receives nerve impulses, that muscle _____.

blood 1783. The contraction of the smooth muscles in the blood vessel helps direct the flow of _____ along its course.

blood 1784. Hence, an additional function of smooth muscle is to help distribute _____ throughout the body.

blood 1785. A continual supply of fresh blood is needed in various regions of the body. This supply is furnished by the automatic functioning of the _____ vessels.

smooth 1786. The AUTOMATIC contraction of the _____ muscle, contained in the blood vessels, helps to distribute a fresh supply of blood throughout the body.

automatic 1787. A person does not have to "decide" that he will contract the smooth muscles in his blood vessels. It is for this reason we say that the contraction of smooth muscles in the blood vessels is _____.

automatic 1788. The distribution of blood, throughout the body, occurs in an automatic fashion. Various internal organs of the body also function in an _____ fashion.

automatic 1789. The stomach is an example of an internal organ that functions in an _____ fashion.

smooth 1790. That is, we do not have to decide to contract the _____ muscles of the stomach in order to digest food.

automatic 1791. Similarly, the contraction of the smooth muscles in the intestines is not a voluntary response, but is, rather, an _____ response.

autonomic 1792. Recall that the peripheral nervous system has two divisions: 1) the somatic nervous system, and 2) the _____ nervous system.

somatic 1793. We previously saw that skeletal muscle is controlled by the _____ nervous system.

skeletal 1794. We also saw that a voluntary response, such as raising the hand over the head, results from the contraction of _____ muscle.

skeletal
voluntary 1795. That is, the somatic nervous system causes _____ muscles to contract, thus producing such _____ responses as raising the hand over the head.

smooth 1796. The somatic nervous system controls skeletal muscle whereas the autonomic nervous system controls _____ muscle.

autonomic 1797. The smooth muscle of the body is controlled by the _____ nervous system.

smooth 1798. We previously learned that the autonomic nervous system functions automatically; we now know that it controls the _____ muscles of the body.

smooth 1799. The arms and legs contain skeletal muscles, but the internal organs of the body contain _____ muscle.

autonomic 1800. The internal organs contain smooth muscle which is controlled by the _____ nervous system.

automatic 1801. Because the autonomic nervous system functions automatically and because it controls the internal organs of the body, we can now better understand how the internal organs function in an _____ fashion.

autonomic nervous 1802. That is, nerve impulses are delivered automatically to the internal organs of the body by the _____ system.

contract 1803. The autonomic nervous system controls the internal organs by causing the smooth muscle, contained in them, to _____.

automatic 1804. Instead of exercising voluntary control over our internal organs, they function in an _____ fashion.

skeletal 1805. Responses, such as talking or running, result from the transmission of neural impulses along the somatic nervous system to _____ muscles.

autonomic smooth 1806. However, responses, such as digesting food, occur because the _____ nervous system delivers neural impulses to _____ muscle.

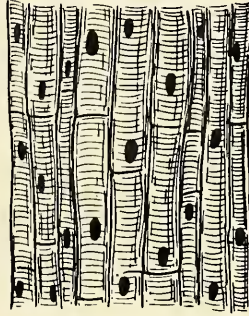
automatic 1807. We are constantly making a large number of automatic responses. Activities like breathing, digesting food, and the flow of blood are examples of such _____ responses.

smooth; skeletal (either order) 1808. We have now considered two of the three types of muscle fibers found in the body. These are _____ and _____ muscle fibers.

Cardiac 1809. The third and last type is called CARDIAC (kär'-dī āk) muscle. _____ muscle is found in the heart.

1810. The word **CARDIAC** refers to the heart. It is for this reason that we call the muscle found in the heart

cardiac muscle



Cardiac muscle tissue

FIGURE 88

1811. In Figure 88, we see a diagram of some _____ muscle tissue.

cardiac

1812. You can see that cardiac muscle looks different from either _____ or _____ muscle.
skeletal; smooth
(either order)

1813. The fibers of cardiac muscle found in the _____ are intimately interwoven.
heart

1814. That is, these fibers form an irregular meshwork—there are numerous complex, and intimate connections among the _____ muscle fibers of the heart.
cardiac

1815. The heart is actually a hollow muscle made up of finely interwoven _____ muscle fibers.
cardiac

1816. Being hollow, the cardiac muscle that composes the _____ contains blood.
heart

1817. Cardiac muscle forms a hollow heart and contains _____.
blood

1818. Like skeletal and smooth muscle, when cardiac muscle receives a nerve impulse, it _____.
contracts

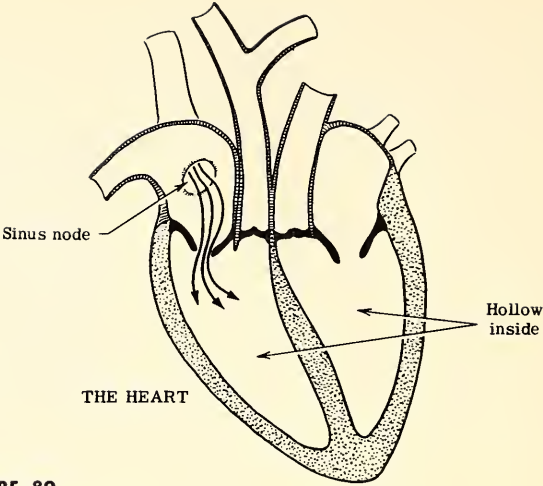


FIGURE 89

1819. In Figure 89, we see a diagram of a human heart _____. Note the SINUS (sī'nəs) NODE.
1820. Nerve impulses are delivered to the heart at the sinus _____.
1821. Nerve impulses, which arrive at the part of the heart called the _____, regulate contractions of the cardiac muscle region.
1822. Recall that the _____ muscle fibers of the _____ are intimately connected in an irregular meshwork.
1823. Thus, when CONTRACTIONS start at the sinus node, those _____ spread to other fibers throughout the heart.
1824. That is, an initial contraction at the sinus node gradually spreads to the intimately inter-connected muscle fibers in the rest of the _____.
1825. The hollow muscle that makes up the heart starts to contract at the _____, and these contractions spread throughout the rest of the heart.

blood 1826. When the muscle fibers of the heart contract, pressure is produced on the _____ that is inside it.

heart 1827. The increased pressure on the blood inside the heart, forces the blood out of the _____ and into the blood vessels.

blood 1828. Once blood is forced out of the heart, it is carried along the _____ vessels by the systematic contraction of the smooth muscle contained in those vessels.

heart 1829. Recall that there is a center in the medulla controlling heart rate. This center automatically sends nerve impulses to the part of the _____ called the sinus node.

medulla; sinus node 1830. These impulses come regularly from the center in the _____ to the _____ of the heart.

regular 1831. These impulses function to REGULATE the heart rate. That is, their REGULAR arrival at the sinus node causes the heart to beat in a _____, rather than random, fashion.

cardiac 1832. Contractions that start at the sinus node spread throughout the numerous, intertwined _____ muscle fibers of the heart.

pressure 1833. The contraction of the entire heart produces _____ on the blood contained inside.

vessels/stream 1834. The increase in pressure then forces the blood out of the heart and into the blood _____ of the body.

EFFECTORS

Section XVI: The Glands

muscles; glands 1835. We know that there are two general types of effectors: _____ and _____.

*skeletal; smooth
cardiac
(any order)* 1836. We have now considered the three types of muscles: _____, _____, and _____ muscles.

glands 1837. It now remains for us to consider the second general type of effector, namely, the _____.

automatically 1838. We have seen how the smooth and cardiac muscles work automatically. Like these types of muscles, the glands also function _____.

secrete 1839. By this, we mean we do not have to "decide" that a certain gland will secrete its product. Rather, glands _____ their product without our "deciding" that they should.

sweat 1840. For example, we know that sweat glands secrete _____ automatically.

adrenalin 1841. We also know that the internal portion of the adrenal gland automatically secretes the product called _____.

automatically 1842. There are two types of glands in the body, and both types function _____.

two 1843. When either of these _____ types of glands secrete their product, we say that a response results.

gland 1844. The first type of gland is called a duct gland, whereas the second type is called a ductless _____.

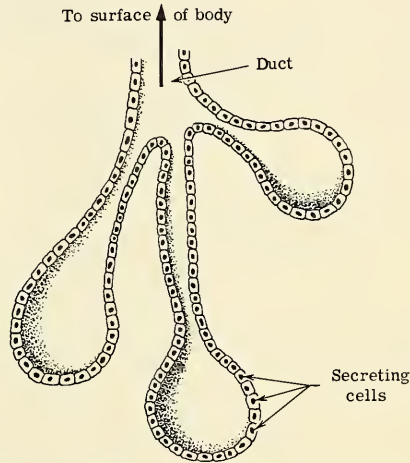


FIGURE 90

duct 1845. A duct is a small tube. In Figure 90, note how the duct connects with the type of gland that we call a _____ gland.

duct/tube 1846. When the duct gland is activated to secrete its product, the product leaves the gland proper and flows through the _____, shown at the top of Figure 90.

duct gland 1847. The product is then carried from where it is generated in the _____, through the duct to the SURFACE of the body.

surface 1848. The sweat gland is an example of a duct gland. Sweat is manufactured in the sweat gland and transmitted through the attached duct to the _____ of the body.

sweat gland 1849. One example of a duct gland is the _____.

- salivary* 1850. The SALIVARY gland is another duct gland. SALIVA is manufactured in one type of duct gland, called the _____ gland, and is conducted through the attached duct into the mouth.
- saliva* 1851. Because the inside of the mouth is continuous with the outer skin of the body, we can consider it part of the surface of the body. Salivary glands secrete the product called _____ into the mouth.
- duct* 1852. Because it secretes its product to the surface of the body, the tear gland is another example of a _____ gland.
- tear* 1853. Tears are manufactured by the _____ gland. The tears are then carried through the tear duct of the lower eyelid into the eyes.
- duct* 1854. Ex derives from the Greek word meaning OUT OF, or OUTSIDE. Another name for _____ glands is EXOCRINE (ěk'sō krīn) GLANDS.
- exocrine* 1855. Because they secrete their product out of, or to the outside of, the body, duct glands are also called _____ glands.
- sweat/salivary* 1856. The tear gland and the _____ gland
exocrine are examples of duct, or _____ glands.
- exocrine* 1857. Another name for duct glands is _____ glands.
- exocrine* 1858. The two types of glands are: 1) duct, or as
ductless they are also called, _____ glands, and
2) _____ glands.
- not* 1859. Duct glands have ducts that secrete their product to the surface of the body. Ductless glands, on the other hand, do _____ have ducts.

ductless glands 1860. Because they lack ducts, the second type of gland is called _____.

exocrine ductless 1861. Another name for duct glands is _____ glands, whereas an alternative name for _____ glands is ENDOCRINE glands.

endocrine 1862. We saw that the EX of exocrine derives from the Latin word meaning OUTSIDE. In like manner, the ENDO of _____ derives from the Greek word meaning WITHIN.

endocrine/ductless 1863. Whereas the exocrine glands secrete their product to the outside of the body, the _____ glands secrete their product within the body.

not 1864. The product of the endocrine glands is _____ secreted to the surface of the body.

ducts 1865. Endocrine glands lack _____, and secrete their product inside the body.

products 1866. Where, inside the body, do the endocrine glands secrete their _____?

endocrine products 1867. The answer is that the _____ glands secrete their _____ directly into the blood stream.

blood 1868. The endocrine glands do not have ducts, but rather, secrete their products directly into the _____ stream.

endocrine glands 1869. The blood stream can then distribute the products of the _____ to a wide variety of places throughout the body.

products 1870. The blood vessels distribute blood throughout the body. Contained in the blood are the _____ secreted by the endocrine glands.

endocrine glands 1871. The products secreted by the _____ are chemical compounds called **HORMONES**.

hormones 1872. Endocrine glands secrete chemical compounds called _____.

hormones 1873. Chemical compounds called _____ are manufactured by the endocrine glands, and are secreted directly into the _____ stream.

hormones 1874. Once these _____ enter the _____ stream, they are widely distributed throughout the body.

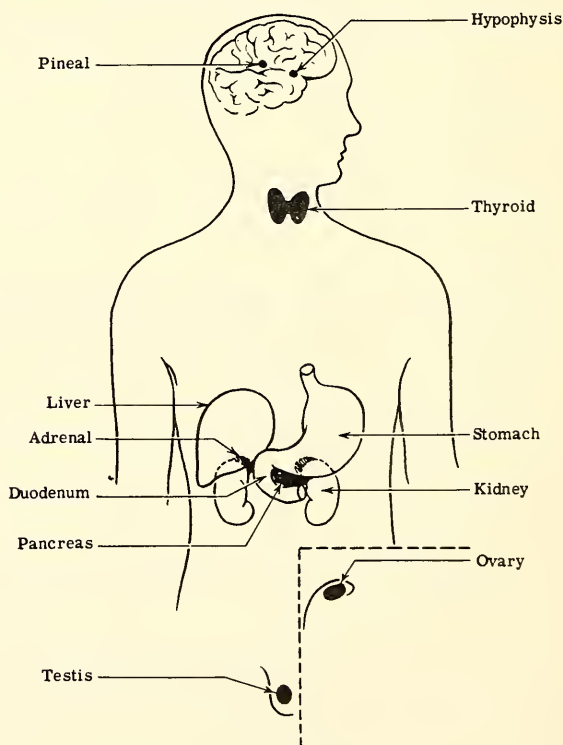


FIGURE 91

endocrine glands 1875. There are a number of different endocrine glands located in various places of the body. In Figure 91, you see where the _____ are located.

- adrenal* 1876. Note, for instance, the adrenal glands. We have already learned that the product secreted by the internal part of the _____ glands is called adrenalin.
- adrenalin* 1877. The name of the hormone manufactured by the internal part of the adrenal glands is _____.
- adrenalin* 1878. As we previously learned, one function of _____ is to cause the liver to release an increased amount of blood sugar.
- adrenal glands* 1879. That is, the hormone adrenalin is manufactured by the _____, then it is secreted into the blood stream, and carried by the _____ stream to the liver.
- hormone*
liver 1880. When the _____ called adrenalin reaches the liver, it causes the _____ to excrete an increased amount of blood sugar into the blood stream.
- blood sugar* 1881. This extra _____ gives the person increased energy to respond in an emergency situation.
- thyroid* 1882. In Figure 91, observe the **THYROID** gland in the neck region. The hormone secreted by the _____ gland is called **THYROXIN**.
- thyroxin* 1883. The thyroid gland manufactures and secretes the hormone called _____ into the blood stream.
- thyroxin* 1884. Excesses and shortages of thyroxin in the blood stream have a number of interesting effects. For example, a shortage of _____ in the blood stream may result in a goiter.
- thyroid* 1885. A goiter is an enlargement of the _____ gland.

thyroxin 1886. What happens is this: When the thyroid gland is deficient, it does not produce enough _____.

thyroid 1887. Because the body demands more thyroxin than is produced by the _____ gland, the thyroid gland must compensate for this deficiency.

thyroxin 1888. In order to compensate for a lack of _____
blood in the _____ stream, an enlargement takes place in the thyroid gland.

hormone 1889. That is, the thyroid gland, located in the neck, grows larger in order to produce an increased supply of the _____ called thyroxin.

neck 1890. As the thyroid gland grows in size, a bump or protrusion can be observed in the region of the _____.

thyroid 1891. This bump, or protrusion, indicates an enlargement of the _____ gland, and is called a goiter.

thyroxin 1892. A person with a deficient output of the thyroid gland has an under supply of _____ in the blood stream.

*increase/
enlargement* 1893. Because his body needs more thyroxin, an _____ in the size of the thyroid gland occurs.

thyroxin 1894. The enlargement of the thyroid gland allows
blood an increase in the amount of _____ to be secreted into the _____ stream.

goiter 1895. The increase in the size of the thyroid gland may be quite noticeable. When we see a bump, or protrusion, in the neck region of a person, we might suspect that the person has a _____.

1896. We have now considered two endocrine glands: the _____ and the _____ glands.
adrenal; thyroid
(either order)

1897. As you can see in Figure 91, there are a number of other _____ glands in the body.
endocrine

1898. This brief consideration of two endocrine glands should give you a general idea of how they all function. That is, they all secrete their particular kind of product, or more specifically, their specific _____ into the blood stream.
hormone

1899. The particular hormone secreted by each _____ has its own peculiar effect on some part of the body.
endocrine gland

1900. In your later work, you should explore the interesting story of how the various _____ glands FUNCTION.
endocrine

1901. For now, it is sufficient to have a GENERAL idea of how the endocrine glands _____ to produce a response.
function

1902. That is, a response occurs when they secrete _____ into the blood stream.
hormones

1903. We have now considered the two general types of glands. When either an exocrine or an _____ gland secretes its product, a _____ occurs.
endocrine
response

1904. For example, a response occurs when the salivary gland secretes _____ into the mouth.
saliva

1905. Similarly, when the tear gland secretes tears into the eyes, or when sweat is secreted by the _____ glands, _____ occur.
sweat; responses

adrenalin
thyroxin

1906. Similarly, a response occurs when the adrenal glands secrete _____ into the blood stream, or when _____ is secreted by the thyroid gland.



Date Due

SEP 17 '66

~~SCIENCE ROOM~~

Due	Returned	Due	Returned
SEP 13 '65	ML SEP 9 '66		
NOV 2 - '65	ML NOV 12 '65		
APR 18 '66	ML APR 21 '66 ML		
MAY 24 '66	ML MAY 24 '66		
JUN - 7 '66	ML JUN 21 '66		
JUL - 5 '66	ML JUL - 6 '66		
DEC 13 '66	ML DEC 15 '66		
NOV 11 '67	ML NOV 13 '67 RE		
APR 8 '68	RE		
	APR - 6 '68 RE		
MAY 9 - '68	RE		
MAY 8 '69	ML JUL 29 '69 RE		
FEB 0 8 '69	FEB 0 5 '69		

131

M148b

C.2

Biological basis of behavior; main
131M148b C.2



3 1262 03319 7665

KEEP CARD IN POCKET

ResLib

ResLib

**IT IS IMPORTANT THAT
CARD BE KEPT IN POCKET**

